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PHLEBOTOMUS SANDFLIES OF THE PALOICH AREA IN THE SUDAN (DIPTERA, PSYCHODIDAE)[1]

By Laurence W. Quate[2]

Abstract: This report describes results of field studies on *Phlebotomus* sandflies from August 1962 to October 1963 in the Paloich area, Upper Nile Province, Sudan about 600 km south of Khartoum. A description of the area is given which includes topography, climate, flora and people. The ecology of the 13 *Phlebotomus* species of the area is summarized and habitat preferences, seasonal occurrences and hosts are described. The changes of the sandfly fauna from the wet to the dry season are discussed and it is concluded that the change is one of addition and subtraction, but not species replacement. Three species of the area, *orientalis, papatasi* and *heischi,* frequently bite man and two species, *clydei* and *schwetzi*, rarely do so. From the medical viewpoint, *P. langeroni orientalis* is the most important form as it is the probable vector of kala-azar. The flight range of *orientalis*, determined by marking flies with fluorescent powders, was at least 730 m. Some flies were also found to reach 1.5-2 m above the ground in free flight. The effects of wind on the man-biting activity of *orientalis* were studied and it was determined that winds below 1.5 m/sec (5.3 kmph) are not deterrent, but between 1.5 and 2.5 m/sec biting activity diminishes and at 4.0 m/sec (14.5 kmph) ceases almost entirely. Average time required for feeding to repletion on man is 4 min 35 sec. A host list has been compiled from cage tests and from the literature. Cavities in trees are the chief daytime resting spots in the wet season; in the dry season soil cracks are used in the day to escape the heat and dessication of above surface locations and foliage of two forest evergreens harbor flies at night. Two and one-half tons of soil were searched for immature stages by direct examination and a sugar flotation technique, but only a single larva of *P. africanus* was found in mud at the base of a tree.

The species are placed in two subgenera, *Phlebotomus* and *Sergentomyia.* Keys, descriptions and illustrations are given for each species and new synonymies are proposed for some named varieties.

At the invitation of the Sudan Ministry of Health, the United States Naval Medical Research Unit No. 3 (NAMRU-3), Cairo in 1960 began studies of kala-azar (visceral leishmaniasis) in the Sudan with the ultimate goal of providing an effective means of controlling and preventing the disease. Under the direction of Drs Harry Hoogstraal and Donald Heyneman, a laboratory was established at Malakal and field studies started in an endemic focus of kala-azar 161 km north—the Paloich area. Since that time a great deal of field work has been done during the dry seasons. Extensive records of man-biting sandflies of the Paloich area have been compiled, preliminary information on the ecology of the species revealed, the vector of kala-azar incriminated and the probable reservoir hosts of the disease found; in addition, clinical and laboratory investigations have been conducted at Malakal and Cairo.

To complement the epidemiological studies of kala-azar it was felt that further ecological studies of the man-biting *Phlebotomus* sandflies should be undertaken and more work done during the rainy season. Aided by a research contract with the Office of Naval Research, the Bernice P. Bishop Museum relieved me of regular duties to participate in the kala-azar research program and devote full time to biological studies of sandflies for 18 months. It was intended that the work would be directed primarily towards man-biting *Phlebotomus*, but it soon became apparent that field work could not be so selective with a group of species not identifiable in the field and which had considerable ecological overlap. Furthermore, to

1. This study was supported by grant number Nonr (G)-00097-62 and 00055-63, Office of Naval Research from Research Project MR 005.09.1603-1, Bureau of Medicine and Surgery, Navy Dept., Washington, D. C. The opinions and assertions contained herein are not to be construed as official or reflecting the views of the Navy Department or the naval service at large. This paper is No. 19 in a series entitled, "Leishmaniasis in the Sudan Republic."

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14. ABSTRACT **This report describes results of field studies on Phlebotomus sandflies from August 1962 to October 1963 in the Paloich area, Upper Nile Province, Sudan about 600 km south of Khartoum. A description of the area is given which includes topography, climate, flora and people. The ecology of the 13 Phlebotomus species of the area is summarized and habitat preferences, seasonal occurrences and hosts are described. The changes of the sandfly fauna from the wet to the dry season are discussed and it is concluded that the change is one of addition and subtraction, but not species replacement. Three species of the area, orientalis, papatasi and heischi, frequently bite man and two species, clydei and schwetssi, rarely do so. From the medical viewpoint, P. langeroni orientalis is the most important form as it is the probable vector of kala-azar. The flight range of orientalis determined by marking flies with fluorescent powders, was at least 730 m. Some flies were also found to reach 1.5-2 m above the ground in free flight. The effects of wind on the man-biting activity of orientalis were studied and it was determined that winds below 1.5 m/sec (5.3 kmph) are not deterrent, but between 1.5 and 2.5 m/sec biting activity diminishes and at .4.0 m/sec (14.5 hmph) ceases almost entirely. Average time required for feeding to repletion on man is 4min 35 sec. A host list has been compiled from cage tests and from the literature. Cavities in trees are the chief daytime resting spots in the wet season; in the dry season soil cracks are used in the day to escape the heat and dessication of above surface locations and foliage of two forest evergreens harbor flies at night. Two and one-half tons of soil were searched for immature stages by direct examination and a sugar flotation technique, but only a single larva of P. africarcus was found in mud at the base of a tree. The species are placed in two subgenera, Phlebotomus and Sergentomyia. Keys, descriptions and illustrations are given for each species and new synonymies are proposed for some named varieties.**		
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confirm the presence or absence of man-biters, studies were made of all the sandflies in different places through the year. From this has resulted much information dealing with the sandflies irrespective of host preference and this report includes the ecology and taxonomy of the fauna of the Paloich area as a whole.

Sixteen months were spent at the Paloich Forward Laboratory and sandfly collections were made during most of this time. Besides observations of live specimens, 46,000 specimens were collected, slide-mounted and identified. During the dry season emphasis was placed on collecting manbiting specimens from human lures, but general collections were made throughout a complete year. At the beginning of the dry season several new buildings were completed to provide more working and living space. Two lab buildings and five huts were built and a guest house renovated to accomodate NAMRU staff and Sudanese technicians working when man-biting sandflies were prevalent.

The Paloich quarters were originally a mission compound. Under the direction of Drs Harry Hoogstraal and Lloyd C. Rohrs, the main building was repaired and made suitable for living and working quarters. A generator was installed and the house wired for electricity. For the extra efforts of NAMRU-3 personnel in renovating the building while carrying out a full schedule of field work, I and my wife are deeply grateful. This gratitude extends to Dr. James A. Boyers, for his unfailing support before and during our occupancy.

Field work at Paloich sometimes was trying because of the isolated position and difficulties in transport and supply. Most supplies came from Cairo and were channelled through the Malakal unit. During the dry season communication with Malakal was over a dirt road, but during the rains this link was impassable and transport was only by the steamer from Melut, 35 km E on the White Nile, or by a small plane of the Mission Aviation Fellowship.

The difficulties and frustrations in this long line of communication were considerably lessened by the generous and thoughtful cooperation of many people and I extend my warm thanks and freely acknowledge my indebtedness to them: Dr Rohrs, HMCS, W. C. Sanders, J. Gray and J. C. Robinson while they were in charge of the Malakal unit; Mr V. Laird, Sudan Interior Mission, Melut; Mr J. Ducker, M. A. F.; Drs Boyers, Hoogstraal and E. McConnell, and especially to Lt D. R. Dietlein and Mrs M. L. Schmidt, NAMRU-3.

Drs Hoogstraal and McConnell and Lt Dietlein gave freely of their assistance in accumulating field data during the dry season and helped orient the research by their discussions and advice. Mr Sobhy Gaber, HMCS George Malakatis of NAMRU-3, Cairo and Sudanese assistants, James Odol, Philip Agak, Joseph Mayon and Manoah Mugo, conscientiously aided through all or part of the time in Paloich and without them the laborious collections could not have been accomplished on as large a scale.

The pleasant companionship and competent assistance by my wife, Stella, prevented drudgery from becoming a part of the work carried out over a long period in an isolated post with few conveniences.

I had the privilege of studying the Parrot collection of sandflies at the Pasteur Institute of Algiers. To Dr R. Neel, Director, Dr J. Grosset and others of the Institute staff, I extend my thanks for a profitable and pleasant stay in Algiers.

LITERATURE REVIEW

There is an extensive body of literature on the Ethiopian phlebotomines, but most of this deals with taxonomy. Before the work of NAMRU-3, biological information on Sudanese species was scanty and dealt mainly with habitats, hosts and seasonal occurrence. This is summarized by Kirk & Lewis (1951). A more recent review of sandfly ecology as it relates to disease transmission is given by Adler & Theodor (1957).

A series of papers under the leading title " Leishmaniasis in the Sudan Republic " has covered accomplishments by NAMRU-3 in the kala-azar program and contains the most significant ecological data on Sudanese phlebotomines to date. A list of man-biting sandflies in the Paloich area and some of their habits are described by Hoogstraal, Dietlein & Heyneman (1962). Further ecological data and evidence incriminating *Phlebotomus orientalis* and eliminating *P. papatasi* as vectors of kala-azar is presented by Hoogstraal & Dietlein (1963) and Heyneman (1963). The seasonal incidence of sandflies in Malakal and the Dinka village of Tir is given by Dietlein (1964). An outline of the entire NAMRU-3 program by Heyneman (1961) focuses attention on research objectives. Progress towards elucidation of the epidemiology of Sudanese kala-azar is presented by Hoogstraal and co-workers (1963).

Immature stages of Sudanese sandflies have been found only by King (1913, 1914) in the northeast near Port Sudan. Hanson (1961) cogently reviews the world-wide knowledge of phlebotomine immatures as a preface to his excellent work on breeding sites of Panama sandflies.

After a series on the taxonomy of Sudanese *Phlebotomus*, Kirk & Lewis (1951) published a comprehensive and valuable taxonomic review of Ethiopian sandflies with keys, descriptions, illustrations and complete bibliography of all species known from Africa at that time. This useful work has greatly assisted taxonomic

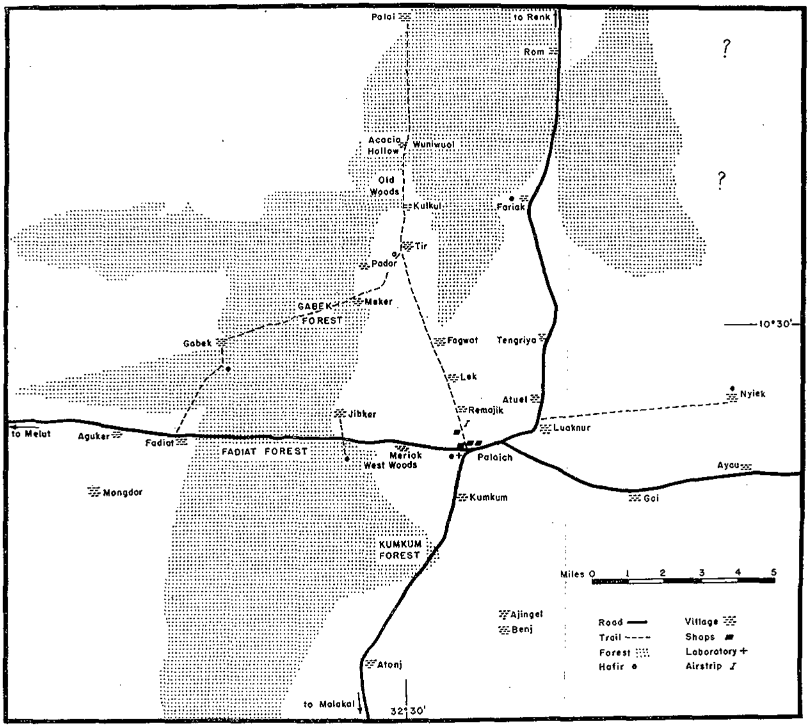

Fig. 1. Map of the Paloich area. Distances measured by jeep speedometer, directions by hand compass.

work vital to the research program undertaken. A few subsequent papers by the same authors (Kirk & Lewis 1952; Lewis & Kirk 1957) and Qutubuddin (1960, 1961) add some species, descriptions and Sudan distribution records to the taxonomic literature.

THE PALOICH AREA

Paloich, site of NAMRU-3 Forward Laboratory, is in the Upper Nile Province of the central Sudan 560 km S of Khartoum and 35 km E of Melut on the White Nile at an elevation of 381 m (fig. 1). It is in the central plains characterized by alluvial, cracking clay soil, which is covered by vast sweeps of grass on a monotonously flat landscape broken by irregular and discontinuous tracts of *Acacia* forests. The level topography is shown by a mere difference of 8 m between points 141 km N and S of Paloich and a drop of only 78 m in the 1200 km between Juba in the southern Sudan and Khartoum.

In the central Sudan the year is about equally divided between dry and wet seasons (fig. 2). The mean annual rainfall of Paloich is 600 mm with a mean annual variation of 80 mm (Barbour, 1961). This falls almost entirely from May to October, although rains may commence in April (as in 1963). During the humid rainy season there is frequent cloud cover and southerly winds. The impervious clay soil allows little seepage when saturated and the flat terrain gives poor drainage outside the scattered water courses, and large parts of the land stand under water through much of the wet season.

In October the rains cease and there begins a period marked by clear skies and cool north winds which continue with gradual warming to February or March.

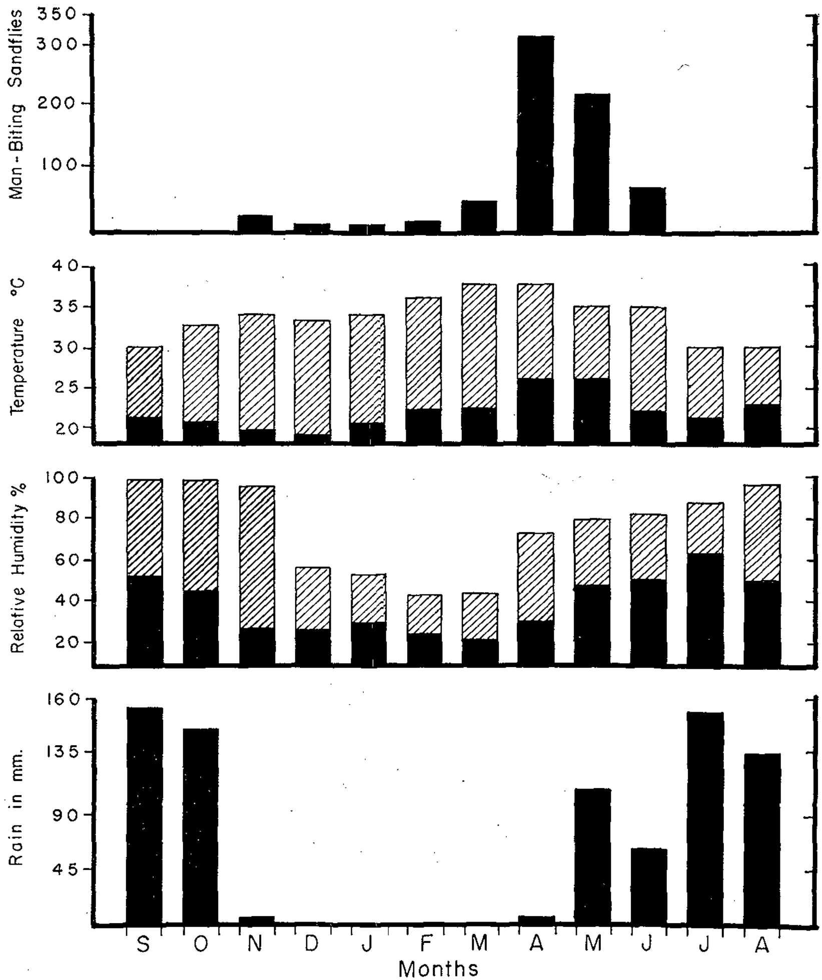

Fig. 2. Climatological data recorded at the Paloich station and man-biting sandflies based on total collections in the area. Solid black bars on R. H. and temperature rows represent average daily minimums per month and diagonal sections average daily maximums.

Under the relentless sun the heavy clay soil dries extremely hard and the surface becomes rent with large cracks as deep as 1 m and with finer fissures below. The visible moisture line recedes to the bottom of the cracks. The grasses turn brown as they die or become dormant and most of the leafy plants lose their foliage. The only greenery during the dry season is on the scattered evergreen shrubs and vines in the forests. March to May is the hottest part of the year, when the cooler winds give way to warmer southerlies which bring with them increased humidity and scattered afternoon clouds.

With the first significant rainfall of the season, the grasses almost overnight begin their annual growth as a green carpet spreads across the land and the deciduous trees quickly regain their leaves. The grass grows profusely during the rains and uncultivated areas are covered with a grass cover of 1–3 meters. Cultivated crops are sown at this time and harvested for several months after the rains cease.

There may be considerable variation in the rainfall between small, adjacent areas. Two examples will support this conclusion, but with only a rain guage at Paloich, I cannot give statistics for other areas. In September 1962 there were 19 continuous days without rain around Melut and at the same time in Paloich rainfall was normal at about 25 mm a week. The boundary where the rain stopped was abrupt and readily observed by the poor grass and crop growth and dry, firm road on the Melut side. In August 1963 Paloich again had normal rainfall, but 5 km north and beyond there was a drought severe enough to hamper the growth of the hardy sorghum. Where there was rain the road was soft and covered with water in low areas but north of that the road was dry and places filled with water at the same time a year ago weie entirely dry. The sharp contrast between rainfall in local aieas is probably a general pattern in the wet season and must certainly have a strong influence on insects breeding or living in the ground.

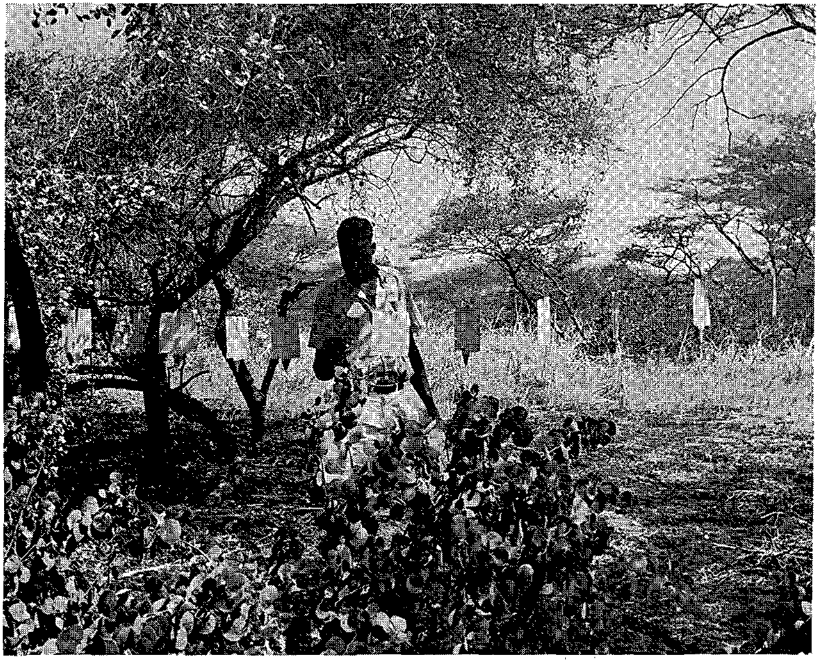

Fig. 3. The *Acacia* forest of " Old Woods Site." *Boscia senegalensis* shrub in foreground; *Capparis* vine growing in *Acacia seyal* tree at left. Assistant is collecting sandflies from suspended oiled tin traps.

In the dry season the overall climate is more uniform, but distinct differences in evening temperatures were noted between Gabek Forest and Paloich, a distance of about 8.5 km. On at least several nights the forest was as much as 5°C cooler. Whether this is a general phenomenon between forests and grasslands I am unable to state.

The study area is in the *Acacia seyal-Balanites* Woodland Savannah vegetational zone of Harrison & Jackson (1958) or the Acacia Tall Grass Forest zone of Andrews (1948). It includes grass savannah and forest. The most abundant forest woody plant is *Acacia seyal*, a thorny tree growing to about 6.5 m with smooth reddish or grayish bark. (*Acacia mellifera* listed by Hoogstraal, Dietlein & Heyneman (1962) is a misidentification of *A. seyal*.) Next numerous and far less abundant is a larger tree, *Balanites aegyptiaca*, which attains a height of about 9.5 m. The bark is coarse and many trees have decayed cavities. In isolated areas of the forest are found stands of *Acacia fistula*, a little larger than *A. seyal* with smooth, whitish bark. All of these trees are deciduous and shed their leaves during the dry season. Foliage remains only on two evergreens: *Boscia senegalensis*, a broadleaf shrub which grows about 3.5 m high and is widely distributed through the forests, and the less common *Capparis* sp., a vine which grows upon and is supported by the trees.

In the forests the trees are generally widely spaced, but in places there are thickets of trees and shrubs. In the open forest with its simple canopy there is not enough shade to prevent a luxuriant grass growth. After the rains the grass cover loses its compactness as it dries and is thinned by being wind-blown or trampled by livestock. Consequently much of the ground becomes covered with straw. Large areas are burned annually, but there is less burning in the forests than the grasslands, and the whole area is not burned in a single season.

The grasslands are composed of different species of grasses, each with its own occurrence determined by soil, relief and drainage, but they constitute a single unit as far as the distribution of sandflies is concerned, except the artificial niches created by the " hafirs, " water reservoirs. These are the only bodies of water in the dry season other than river and drainage courses, and affect the distribution of certain sandflies.

Villages are inhabited by Nilotic Dinkas, the permanent residents of the Paloich area aside from the Arab merchants and few Shilluks at Paloich. The village sites are on elevated, well drained ground and all are outside the forests except a few smaller ones. Their only buildings are " tukls," circular mud huts with dirt floors and grass roofs. Human tukls, about 4.5 m in diameter, are built on the roughly circular periphery of the village and the much larger animal tukls, which shelter livestock at night, are located inwards around the central clearing where the animals are tied in the heat of the day after grazing. Floors of human tukls are packed hard and smooth, but those of the animals are covered with loose dirt and excreta. The ground within the village is well drained and dries quickly after a rain; in the dry season it is uncracked as continual trampling keeps the cracks filled. Where the animals are tethered in the central clearing, the dirt is mixed with animal excreta. Most of the fresh droppings in the animal shelters and outside are collected and dried daily by the young boys for smudge fires to protect the animals from bloodsucking pests. Except for a few *Balanites* or similar trees in nearly all villages, the ground is bare of vegetation, but grass grows within a few feet of the outermost ring of tukls. Scattered holes from which dirt has been taken for mud pockmark the ground surrounding the villages.

Villages vary in size from as few as ten tukls to more than 100. The smaller ones, as Wuniwuol, Kulkul and Pador, are usually within or near the forest, but most are usually located outside wooded areas and often at considerable distances. Tir is the largest village near the forest in the Paloich area and in some important respects its sandfly fauna is intermediate between the forest and grassland villages. All are essentially as described above and differences of location, size and age do not seem significant to the view, but obviously there are important microecological differences as evidenced by differing sandfly faunas.

Dinkas are a conservative people reluctant to modify their traditional cultural patterns. Cattle are their most highly valued possession and their mode of life is adapted to the needs of the animals. Wealth is measured by the number of cows one owns and it is impossible for the men to obtain a bride without them. Sheep and goats are secondary in value, but also constitute wealth to Dinkas. Livestock are not slaughtered for food except on special occasions, such as weddings. A form of cheese, sorghum (" dhura ") and maize are their staple foods.

A seasonal movement of the Dinkas is dictated by the needs of their cattle. When the dry season is well advanced and the rain pools have dried up, the hafirs provide insufficient water for both humans and animals. At this time the younger men and women take the cattle to the " toich," flooded grazing grounds aside the Nile, and villages are depopulated or entirely deserted. Some villages are also vacated as nearby hafirs dry up and people move to other places nearer water.

Although most of the Paloich Dinkas have their homes in the grasslands, there is constant movement of all ages, except apparently the very young, into the

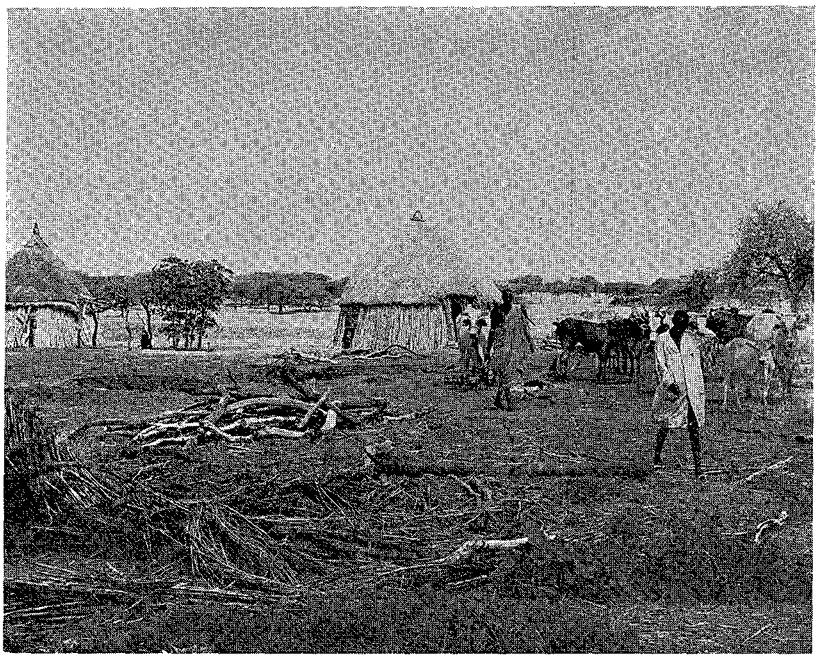

Fig. 4. Wuniwuol village and "Acacia Hollow" in background.

forests. Significantly, they are often there by sunrise and at dusk, which are times when sandflies may be biting. Fields require attention by men and women, firewood and water must be brought back to the village daily by women and girls, and livestock (goats and sheep only in the dry season) are herded and grazed there by younger boys. Living in villages of the grasslands does not exclude the likelihood of the people being exposed to man-biting insects in the forests at frequent intervals.

During 1962–63, many places in the Paloich area were visited regularly for sandfly collecting. These places include grassland and forests and are located on the map (fig. 1). Most of the grassland sites are villages, but some are in open, uninhabitated areas which include two hafirs. The land around the hafirs is low and undrained, so is usually flooded for the last several months of the rains. The forest is about 3 km from the Paloich hafir and about 1 km from the one at Tir, although here there are scattered *Balanites* trees and the area apparently was forested at one time.

Since sandflies in general are more abundant in the forest and *P. orientalis*, an important man-biter, is largely confined there, most collecting sites are in or near wooded areas. The forest containing these sites is part of a continuous one which begins far north of Paloich, passes to the west of Tir, curves gently eastwards and then westwards and continues south of the study area.

Forested areas include "Acacia Hollow," "Old Woods Site," "Gabek Forest," (discussed by Hoogstraal & Dietlein, 1963), "Westwoods," "Fadiat Forest," and "Kumkum Forest." Acacia Hollow (fig. 4) is a shallow depression 180 m W. of Wuniwuol with a sparse stand of *A. seyal* and few *Boscia*. It is flooded during the rains and grass is sparse. Many rodent nests are in the cracks just beyond the edge of the depression[1]. Old Woods Site (fig. 3) is 1.4

1. Except for the *Acomys* colonies from which several young were taken while excavating, I am unable to identify the rodent burrows or nests. Species trapped in the area by NAMRU-3 members are *Acomys albigena* Heuglin, *Arvicanthus niloticus luctuosus* Dollman, *Mastomys natalensis ismailiae* (Heller), and *Tatera flavipes* Allen.

km S. of Acacia Hollow. The trees are relatively dense and include *A. seyal* and *Balanites;* there are many *Boscia* and *Capparis* thickets mixed with *A. seyal* and the grass cover is thick. Few rodent burrows were observed.

Gabek Forest is a 3.5 km strip through the forest between the Tir hafir and Gabek village. *Balanites* trees dispersed among the thicker *Acacia*, shrub and vine thickets, and a thick grass cover gives it a parkland aspect. The dry season soil cracks are smaller than in the grassland and the soil surface is softer. Rodent burrows are common but scattered. On the west edge of the forest, where the soil is friable and much of it uncracked, there is a stand of *A. fistula* mixed with the other trees. Many colonies of *Acomys* are found here.

Westwoods is the forest nearest to Paloich about 3.5 km west. The woody plants are almost entirely *A. seyal* with only a few *Balanites* and no shrubs. In parts where the *Acacia* trees are especially thick, they are small and the only ground cover is a low, spreading annual which dies back and leaves the ground bare in the dry season. No rodent burrows were seen. Fadiat Forest is 5 km further west. The vegetation is largely grass, *Balanites* and *Boscia* thickets and *A. seyal* seems to have been eliminated long ago by burning and cultivation, although now little ground is cultivated.

Five kilometers S of Paloich a spur of forest crosses the Malakal road and is designated Kumkum Forest. An almost pure stand of *A. fistula* is on the margin and inwards gives way to the usual *A. seyal-Balanites* mixture. *Boscia* is infrequent, grass cover is tall and thick, and few rodents nest in the soil cracks. Cracks are small as in most of Gabek Forest, but unlike the uncracked, friable soil in the *fistula* area of Gabek.

Part I. Ecology

PHLEBOTOMUS SPECIES OF THE PALOICH AREA

The following section is made up partly of conclusions derived from information presented in detail later and partly of observations applicable to individual species not included elsewhere.

Sex ratios of wild caught flies on oil papers and trees are given in Table 2, but repellency of the oil or different catches due to behaviorial differences of the sexes may give a distorted ratio in some cases.

Phlebotomus (*Phlebotomus*) *langeroni orientalis* Parrot. From the viewpoint of disease transmission, this is the most important sandfly in the Paloich area. Man is readily bitten by it. Wild-caught flies have been incriminated as vectors of kala-azar (Hoogstraal & Dietlein 1963) and Heyneman (1963) shows its potential as an effective agent for the spread of *Leishmania*. Rodents and lizards are also its hosts. The species is numerous only in the dry season, but in the rainy months adults are found occasionally. The *Acacia-Balanites* forests are its main habitat (Table 1); it is abundant in Acacia Hollow, Old Woods and Gabek Forest and villages near or in these forests (Wuniwuol, Kulkul, Pador & Meker), moderate in Fadiat Forest and scarce in Westwoods and Kumkum Forest. In villages its numbers decrease as they are farther removed from the forest, but a few are found even in the grasslands villages of Nyiek and Ayau. It appears that the main breeding sites of *orientalis* are in the forests, but specific spots are still unknown in spite of intensive searches for them.

Phlebotomus (*Phlebotomus*) *papatasi* Scopoli. Although a severe man-biter, *papatasi* seems to be mainly a nuisance in the Paloich area and evidence indicates it is not a vector of kala-azar (Heyneman 1963). It is a vector of cutaneous leishmaniasis and sandfly fever in other parts of the Old World (Adler & Theodor 1957). This is a dry season species mainly found in grassland villages; mixed populations of it and *orientalis* are found in old, established villages near forests, as Tir, and it is seldom found within the forest proper (Hoogstraal & Dietlein 1963). It is usually numerous in the villages of Nyiek and Ayau (Hoogstraal & Dietlein, l.c.), but was scarce in 1963. Breeding places may be within or near the villages.

Phlebotomus (*Phlebotomus*) *heischi* Kirk & Lewis. A dry season, man-biting species, *heischi* first appeared in significant numbers in the Paloich area in 1963. This was in contrast to 1961 and 1962 when only a few were collected in some of the identical areas where it was found in 1963. It seems to reach its peak of abundance during February and March and diminishes a month earlier than other man-biters. It is limited to certain forest areas (Table 1), being moderately numerous in the west part of Gabek and Kumkum Forests, scarce in Acacia Hollow, Old Woods Site, most of Gabek and Fadiet Forests and absent from Westwoods. It was always collected in association with *orientalis* on human lures where it made up 5–30% of mixed collections, except in Kumkum Forest where it outnumbered other man-biters. *Acacia fistula* seems to be an indicator for most *heischi* habitats, although the distribution of the two is not entirely coincident. Besides man, the species feeds on other mammals and lizards.

Phlebotomus (*Phlebotomus*) *rodhaini* Parrot. During the three years sandflies have been collected in the Paloich area, only 140 specimens of this species have been taken. All were from oil papers of tree trunks, except three from human lures and it is questionable if these were biting. This is a dry-season forest species. Eighty-nine per cent of the specimens was taken in forest, 9% in villages near forests (including Tir) and only 2% in grassland villages (Nyiek & Ayau). The

relatively high percentages taken on oil papers where rodents are numerous lead me to suspect that this species feeds on these mammals.

Phlebotomus (*Phlebotomus*) *duboscqi* Neveu-Lemaire (=*P. roubaudi* Newstead). Only 5 males of this species have been collected by oiled papers in the Paloich area at Gabek Forest, Tir & Paloich from 1961–63. As the females are difficult to distinguish from *papatasi* (see Abonnenc 1959), some females of *duboscqi* may have been misidentified as that species. However, the males are distinctive and from their low numbers I assume this is a rare species in the study area. Nothing is known of its habits.

Phlebotomus (*Phlebotomus*) *lesleyae* Lewis & Kirk. Only a single female of this species was collected at Tir on oiled paper in December 1962. Nothing is known of its habits.

Phlebotomus (*Sergentomyia*) *clydei* Sinton. This widespread, dry season species is predominatly a forest dweller, but is also fairly numerous in grasslands and of villages and in grasslands away from villages or trees, but reaches its greatest densities in forests (Table 1). In human and animal dwellings, the sex ratio is disproportionately high for females and they are probably attracted there to feed on skinks and geckoes and not for breeding. There are a few authentic records of *africanus* feeding on man (Hoogstraal *et al.* 1962), but its main hosts are cold-blooded animals.

Phlebotomus (*Sergentomyia*) *antennatus* Newstead. Another common, non-seasonal species, *antennatus* is present in the area 12 months of the year. Distribution is about equal through the major habitat types, but slightly more numerous near hafirs (Table 1). As with *africanus*, the sex ratio indoors indicates it is attracted there for feeding. It is known to feed only on cold-blooded animals and has never been recorded biting man or other mammals.

Phlebotomus (*Sergentomyia*) *bedfordi* Newstead. This species is rare in the Paloich area, although present the whole year. It has been found only in forests and villages (Table 1). In forests it was most abundant in Acacia Hollow, Old Woods and Gabek Forest. It seems to feed equally as well on warm-blooded as on cold-blooded animals. Man was infrequently bitten by *clydei* in our study.

Table 1. Abundance of sandflies in various habitats. Average number of sandflies per 100 oiled papers.[1]

Phlebotomus Species	Forests	Hafir (Reservoirs)	Grassland Villages[2]	Tir	Village Inside 62—63	Village Inside 61—62	Village Outside 62—63	Village Outside 61—62
orientalis	19.5	0.3	—	—	0.05	0.07	0.02	0.03
heischi	1.4	—	—	—	—	—	—	—
rodhaini	0.6	—	—	—	—	—	—	—
clydei	13.5	3.2	0.9	3.2	1.9	0.9	2.6	4.2
adleri	0.01	1.2	—	—	—	—	—	—
africanus	13.5	5.7	3.0	2.5	2.7	3.0	2.4	1.2
antennatus	5.2	8.1	3.8	6.0	9.2	3.5	3.4	3.0
bedfordi	0.2	0.1	—	—	—	—	—	—
schwetzi	15.5	3.0	0.5	0.2	0.3	1.6	1.7	1.3
squamipleuris	9.4	28.7	2.0	2.1	0.3	—	4.2	—

[1] Collections from Aug. 1962 to July 1963, except 1961-62 collections at Tir (from Dietlein, 1964). Figures valid only for relative abundance within each species and not for interspecies comparisons.
[2] Meriok, Paloich, Remajiy, Lek & Fagwat.

Phlebotomus (*Sergentomyia*) *adleri* Theodor. A relatively rare species in the area, *adleri* is found almost always near hafirs (water reservoirs), seldom in the forests and not at all in the villages or grasslands away from hafirs. It was first collected at the end of the rains in October and then through the dry season. Occasionally it might feed on man.

Phlebotomus (*Sergentomyia*) *africanus* Newstead. Throughout the year, *africanus* is one of the most common sandflies in the area. It is found in all types near hafirs (Table 1). It feeds largely on cold-blooded animals, but occasionally bites man. Males are almost identical to those of *antennatus* and it is possible the sex ratio (Table 2) is incorrect as some males may have been misidentified as *antennatus*.

Phlebotomus (*Sergentomyia*) *schwetzi* Adler, Theodor & Parrot. Although a few specimens were found in all months, *schwetzi* is a seasonal species that reaches its maximum numbers in the latter part of the dry season and persists longer into the rains than other seasonal species. It is chiefly a forest species abundant in all wooded areas, except the west part of Gabek and Fadiat Forests, but is also well represented in grasslands and villages (Table 1). Known hosts include warm and cold-blooded animals and it frequently bites man.

Table 2. Sex ratios of Paloich sandflies, ♀♀ : ♂♂.

Phlebotomus species	Oiled Papers	Tree Trunks	Combined O.P.+T.T.	No. of Spec.
orientalis	19 : 81	29 : 71	19 : 81	1621
heischi	60 : 40	—	—	115
rodhaini	30 : 70	—	—	57
clydei	54 : 46	44 : 56	53 : 47	1171
adleri	33 : 67	—	—	47
africanus	66 : 34	72 : 28	70 : 30	10922
antennatus	73 : 27	40 : 60	66 : 34	5438
bedfordi	89 : 11	—	—	53
schwetzi	55 : 45	25 : 75	50 : 50	1520
squamipleuris	55 : 45	62 : 38	55 : 45	789

Phlebotomus (*Sergentomyia*) *squamipleuris* Newstead. This nonseasonal species is most numerous in moist habitats around hafirs, moderately abundant in forests and less numerous in villages (Table 1). It is known to feed only on cold-blooded animals. Of the species in the area, *squamipleuris* is the sandfly most attracted to light and such collections are dominated by it.

SEASONAL DYNAMICS

Methods and materials. 15 cm squares of wax papers were used extensively as sandfly traps. Sticks or straws were stuck through the papers to support them. Tins of the same size also were used when durability was desirable; they were cut with the bottom edge projecting into a short point for their support.

A number of light oils can be used to coat the papers and tins (hereafter called " oiled papers " for simplicity) and form an adhesive surface. Castor and sesame seed oil were used in the present work. Castor oil is longer lasting, but appears to have a repellancy for *P. orientalis*. Larger catches of *orientalis* were obtained with sesame oil traps and it was used exclusively after March 1963, although such traps needed the oil replenished daily. Species other than *orientalis* were taken in about equal numbers regardless of the kind of oil used.

The oiled paper traps were placed wherever population samples were desired, such as over and in soil cracks and rodent burrows, upright or flat on the ground in forests, grasslands and villages, in trees and bushes, and on the walls or ceilings of tukls. As sandflies often move in brief flights and apparently land at short intervals, they alight frequently on randomly placed oiled traps and are entrapped. This trap was first used by Vlasov (1932; *teste* Kirk & Lewis 1940). They are the best method available for making random samples and have been used to compare densities of a species in different habitats and seasons, but not for interspecies comparisons.

When the weather is humid and relatively cool, sandflies are often found resting in cracks and holes of trees. Blowing cigarette smoke into their hiding places disturbs them and they move into view where they can be collected with an aspirator. The necessary weather conditions prevail mainly in the rains and dry season species are seldom collected in this way. The catch on tree trunks is not nearly as random as oiled papers, for it is proportional to the effort expended by the collector and to the number of hiding places on the tree. Nonetheless, tree trunk collections are useful for surveys and showing seasonal changes and have been used for these purposes.

Malaise traps (a tent-like trap; see Gressitt & Gressitt 1962) have been used for collecting psychodids in other parts of the tropics with good results, but did not prove very effective in the Paloich area and had limited usage. While a large number of insects were taken in the traps, the catches of sandflies were not high. The proportion of species taken was similar to oiled paper collections.

Light traps yield mainly *squamipleuris*. Other species are less attracted to lights. Such collections are not representative of the sandfly fauna and were little used in this study.

Data in this section are derived from collections made between 1961 and 1963. Human lures were used in the three dry seasons included in this period. From February 1961 to January 1962 oiled paper traps were continuously operated at Tir village (Dietlein 1964). More extensive collections were made continuously from August 1962 to September 1963 in various localities of the Paloich area using the methods described above.

Results and discussion. The most obvious pattern that emerges from analysis of seasonal changes in Paloich sandflies is that some species occur as adults only in the dry season, " seasonal species," and some are present throughout the year, " non-seasonal species." None are limited to the wet season. The two groups differ not only in periodicity, but in biological (and taxonomic) features as well. The first group, *orientalis*, *papatasi*, *heischi*, *clydei* and *schwetzi*, are seasonal species which feed chiefly, or at least regularly, on mammals. The second, *africanus*, *antennatus*, and *squamipleuris*, are non-seasonal and feed mainly on cold-blooded animals.

Adults of the seasonal species begin to appear in the first part of the dry season, but their numbers remain low during the first few, cool months. They do not become numerous until about March after the hot, dry weather has begun and the average maximum temperature exceeds 35°C. They diminish and disappear as the rains commence. (See fig. 2, man-biting sandflies; fig. 5, *orientalis;* fig. 6.)

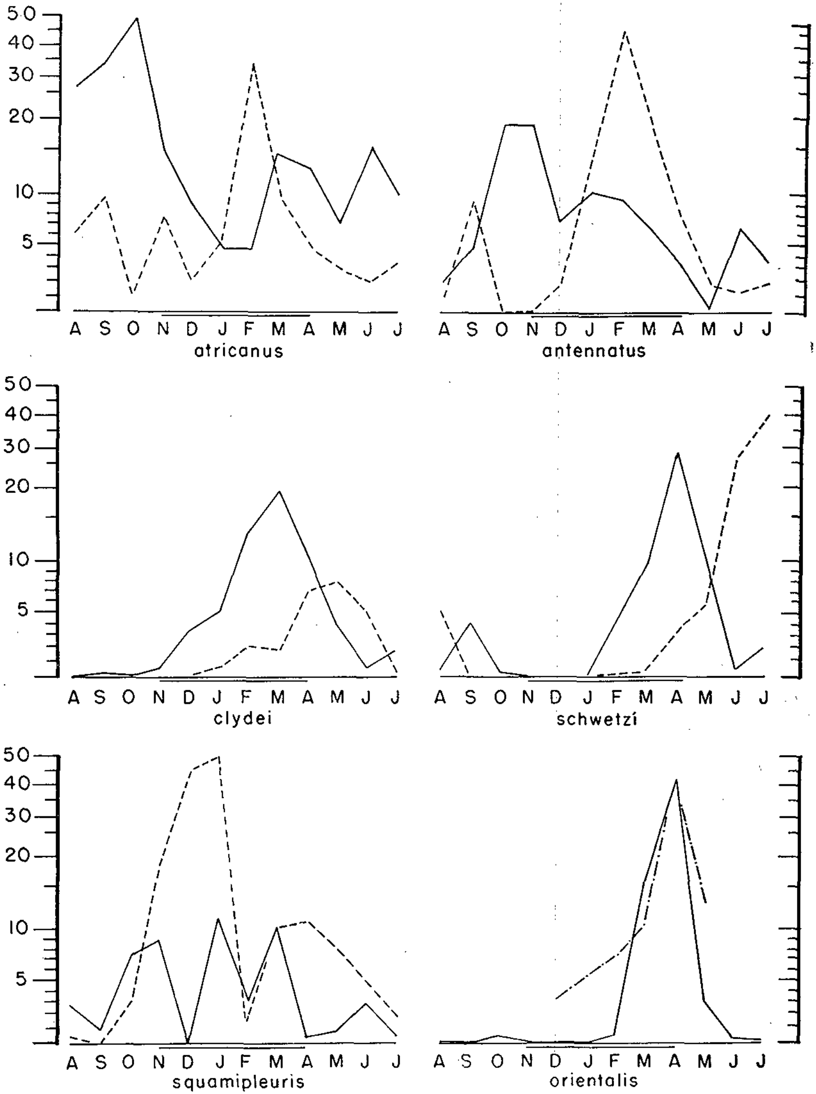

Fig. 5. Relative abundance of the six most common *Phlebotomus* in the Paloich area. Solid lines represent average number of flies per day on oiled papers, on tree trunks and in Malaise traps combined in 1962–63. Broken lines represent 1/10 total monthly catches on oiled papers at Tir in 1961–62, except *squamipleuris* specimens taken in Malakal at light (Dietlein 1964) and *orientalis* specimens from human lures in the Paloich area.

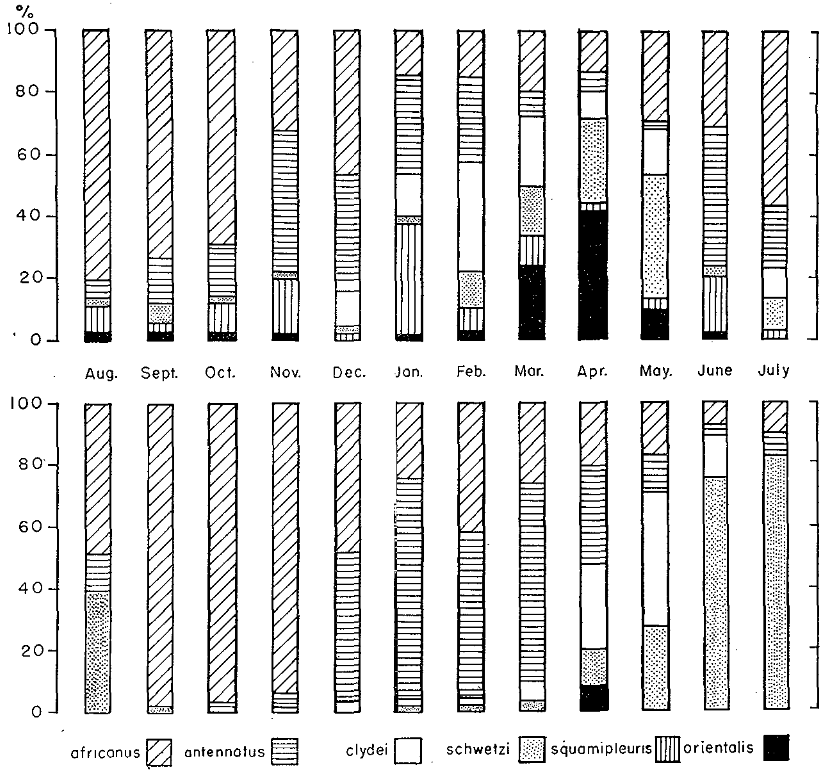

Fig. 6. Composition of sandfly fauna in the Paloich area based on percentages of specimens of each species in monthly catches. Upper row, oiled papers, tree trunk and Malaise trap collections in 1962–63. Lower row, oiled paper collections at Tir in 1961–62 (Dietlein 1964).

This has been the general pattern of population changes of the seasonal species from 1961 to 1963. There are, however, deviations. The abundance of *papatasi* conformed to the pattern in 1961 and 1962 and was a severe pest in some villages, but failed to become numerous in 1963 when its presence was scarcely noticed by villagers and human lures attracted few specimens. Conversely, *heischi* appeared and disappeared with the other species in 1963, but was practically absent in the dry seasons of the two earlier years. The seasonal abundance of *clydei* and *schwetzi* begins at about the same time as the others, but they persist longer at the end of the season.

Almost nothing is known of population fluctuation of the mammals which may serve as hosts of the seasonal sandflies. In the dry season insectivores, rodents, ungulates and carnivores are numerous enough to be commonly trapped or seen. The effects of the rains on these animals are unknown. From limited observations the author has the impression that only the rodents may decrease in the rainy season. Only future research will show if there is a causal relationship between population changes of sandflies and their wildlife hosts.

The non-seasonal species may be as abundant during the rains as the dry season. Their numbers fluctuate

from one month to another and there is little correlation between their monthly abundance in 1961–62 and 1962–63.

Variations in populations of *africanus* and *antennatus* cannot be explained by the major climatic differences of the two seasons. Their numbers are probably affected by minor changes within either of the seasons. While the broad picture of wet and dry seasons remains fairly constant, there are considerable differences within each season from year to year and locale to locale even in a limited area (see discussion of climate). These intraseasonal variations in climate could produce changes in edaphic conditions and microclimate that might have an adverse or beneficial effect on populations of these species which would produce the erratic monthly numbers and irregular curves in fig. 5. Undoubtedly, the true situation is complex and other factors of the ecosystem are important, but with our knowledge of sandfly ecology still in its infancy, further speculation is pointless.

In summary, the annual, cyclical changes of the sandfly fauna consist of addition and subtraction, but not replacement, of species (fig. 6). Some, notably *africanus*, *antennatus*, and *squamipleuris*, are present throughout the year. As the rains end and the dry season commences, the fauna slowly changes by the addition of other species, which include the three man-biters, *orientalis*, *papatasi* and *heischi*. The greatest variety is reached by the middle of the dry season when all of the species of the Paloich area are present and no particular one predominates. During the first part of the wet season, the seasonal species disappear and the fauna returns to a less varied composition with only the nonseasonal species persisting.

FLIGHT RANGE OF *P. LANGERONI ORIENTALIS*

Methods and materials. To determine flight ranges, sandflies in wooden cages were marked with fluorescent powders and released within a few hours. The flies were taken alive from human lures and, of course, identifications could not be made, but there is no reason to believe that the majority were other than *orientalis* which made up the bulk of concurrent and similar collections from the same places.

In two series marked flies were released in Gabek Forest at apices of triangles. In the first the sides of the triangle were 180–195 m long. In the second they were 275, 330 and 380 m. Collecting stations were set up within the triangles 45–335 m from release points. Each night for one week, as weather permitted, teams collected at these stations on human lures.

The advantages of using multiple collecting points within the boundaries formed by multiple release stations is that each point is able to obtain data from all distances and directions from each release station, rather than each collecting point gathering data on only one direction and distance as would be the case if a single release station were used. The design was suggested by Dr W.C. Reeves (personal comm.).

In the third series a line of release points was established in the forest up to 730 m S of Pador village (see fig. 1). Nightly collections for one week after releases, weather permitting, were made on the periphery of the village by three teams. This series was designed solely to learn how far sandflies would travel to reach a village. Attempts to do more along this line were frustrated by cool, rainy weather which prevented getting flies in numbers large enough for marking and releasing.

" Helecon " fluorescent powders[1] were used for marking sandflies following the examples in mosquito studies by Bailey, Eliason and Iltis (1962) and W.C. Reeves (personal comm.). The powders are fine dusts of zinc sulphide base with particle sizes of 2–7 μ. Different pigments show different colors under ultraviolet light. They were applied to the sandflies with a DeVilbiss powder insufflator (No. 119) when the flies were in holding cages. Without the addition of adhesives, the powders adhered well to the body and wings of sandflies for at least a week. No noticeable effects were observed on the longevity or flying ability of the flies. Three powders were used with fluorescent colors of red (Helecon pigment 1757), green (1953) and yellow (2267). The use of blue powder (2200) was abandoned when we had difficulty differentiating it from the green. The source of ultraviolet light for detecting marked sandflies was a " Stroblite " projector lamp[2] consisting of a General Electric mercury black light spot bulb, purpleblue filter and transformer. Radiation of the lamp is in the range of 3650° Angstrom units and after prolonged use no deleterious effects to the eyes were felt.

As contamination with these fine, sticky powders may easily occur, precautions were taken to prevent it. A different colored powder was assigned to each of three teams and each kept their cages and other equipment isolated in separate containers. No member of one team was permitted to handle the equipment of the other. Cages were not used for any other purpose; aspirators were thoroughly cleaned daily before use and ascertained to be free of any contaminating powder by examination under ultraviolet light.

Results. In the three series of tests designed to

1. Manufactured and sold by U. S. Radium Corp., Hanover Ave., Morristown, N. J.
2. Sold by Stroblite Co., 75 West 45th St., New York 36, N. Y.

Table 3. Results of flight studies using sandflies marked with fluorescent powders.

Date	Marked sandflies recovered	Hours after release	Distance & direction flown	Total catch	Numbers marked & released[1]
			Series One		
9/4	0	24		0[2]	1300
10/4	1	48	60 mW	2000	
	1	48	145 mN		
	1	48	155 mNE		
11/4	0	72		205	
12/4	0	96		1040	
13/4	1[3]	120	45 mE	1100	
14/4	0	144		770	
15/4	0	168		1900	
			Series Two		
25/4	1	24	70 mSW	2000	2400
	2	24	190 mSW		
	1	24	300 mS		
	1	24	300 mNE		
26/4	0	48		0[2]	
27/4	1	72	70 mW	1400	
	1	72	180 mS		
28/4	0	96		0[2]	
29/4	2	120	70 mNW	2000	
	1	120	190 mSW		
	1	120	220 mNE		
30/4	0	144		140	
1/5	1	168	230 mNW	2000	
			Series Three		
14/5	1	24	730 mN	150	2600
15/5	0	48		200	
16/5	0	72		0[2]	
17/5	0	96		0[2]	
18/5	0	120		15	
19/5	0	144		75	
20/5	0	168		100	
	17			15095	6300

[1] Released 24 hours prior to listed date, actual counts reduced in allowance for losses during transfer to cages.
[2] Inclement weather prevented collections.
[3] Possibly contaminated after capture.

determine flight distances, 6,300 marked sandflies were released. Subsequently, 15,095 were collected in attempts to recover marked flies. Seventeen marked flies, 0.1% of those released, were recovered 45–730 m from release points (Table 3). The longest period between release and recovery was 7 days. All recoveries were females of *P. l. orientalis*.

Most of the recoveries were made up to 300 m from release points and only one specimen had flown 730 m. It should be noted, however, that most of the work was done under a design in which 300 m was nearly the maximum distance at which recoveries could be made. The maximum distance of 730 m was flown by a single female. Because of the significance of the specimen, special attention was paid to it and the collecting equipment. The specimen was freshly captured as shown by being alive and in good condition without broken appendages or rubbed hairs. No contamination was found in the aspirator in which the specimen was collected and held until examination.

Discussion. It has been assumed that sandflies do not fly more than 90 m on the basis of Young *et al.* (1926) finding breeding sites within that distance of biting adults, or more than 270 m, based on Price & Rogers (1914) finding that removal of workers this distance protected them from sandfly bites. Until

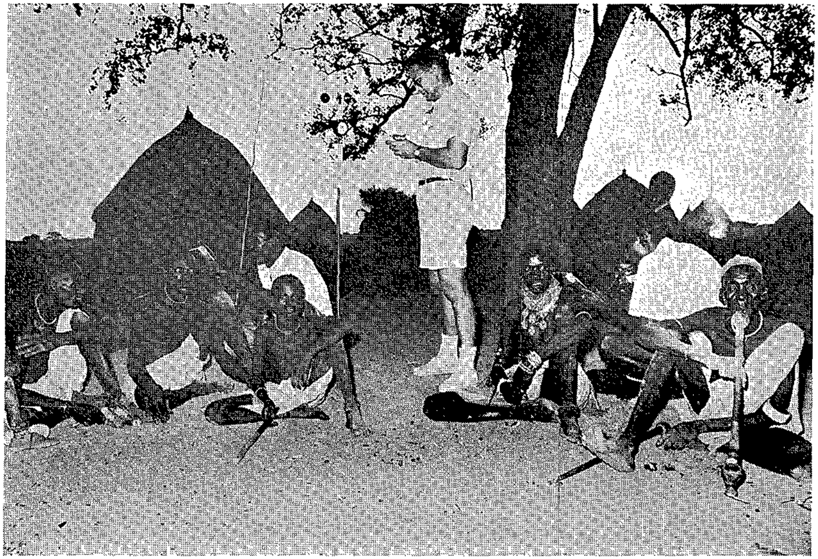

Fig. 7. Collecting man-biting sandflies from human lures in a Dinka village near Paloich. Wind, temperature and relative humidity records being made at time of collecting.

recently there has been no direct evidence on distances sandflies are able to travel.[3] Now, our concepts of the flying ability of sandflies need revision and the theory that they fly only short distances is no longer tenable. However, we still do not know the limits of their flight ranges. In our work, the maximum distances possible in each test were achieved by the flies.

Evening hours when sandflies were being collected and most active were characterized by mild southerly winds and periods of calm. On several evenings, strong southerlies entirely precluded collecting. Although southerly winds did prevail during the course of the work, I have no way of correlating them with sandfly movements. No instruments were available for continuous recording of wind movement and the data do not indicate what influence wind may have on sandfly flights.

FLIGHT BEHAVIOR

Methods and materials. Oiled tins were strung on wires and suspended between trees and poles 0.3–1.5 m above ground to study sandfly flight habits. No specimens were taken from tins at each end of wire which could have been reached by a short flight from the upright support. Most of the work was done in Gabek Forest and Old Woods Site in the dry season, but later repeated in the rainy season at the Paloich compound in an unforested area. Only tins 1.5 m above ground were used in the last test. Traps were checked each morning and evening.

Oiled traps set on the ground for other purposes (see "Seasonal dynamics") and visual observations also yielded data applicable to this section.

Table 4. Sandflies collected in forests on oiled tins suspended at indicated heights and upright on ground.

Phlebotomus species	Ground	0.3 m	1 m	1.5 m
orientalis	6	3	1	4
heischi	2	0	0	2
rodhaini	10	0	0	1
clydei	11	2	12	9
africanus	11	16	11	11
antennatus	4	0	2	0
schwetzi	5	1	3	2
squamipleuris	9	1	2	2
Totals	58	23	31	31

3. A colleague has stated that Russian workers have recovered marked sandflies after a flight of 1450 m, but I am unable to locate the reference.

Results and discussion. From the suspended traps in the forests, 8 species of *Phlebotomus* were taken 0.3–1.5 m above ground. Specimens were nearly as numerous there as on ground traps immediately below the elevated ones (Table 4). The catches at Paloich (Table 5) contained fewer species since they were during the rains, but also showed a high number of flies attaining 1.5 m in free flight. In the latter, there was no nearby vegetation which could have been used to achieve the indicated heights. The results of the two studies demonstrate that sandflies regularly fly more than a meter above the ground.

The most obvious flight pattern of sandflies is a series of short, erratic hops in which the fly seldom rises more than a half meter above a firm surface. This is the movement exhibited in situations where these small flies can be observed. The large number of flies captured on oiled papers on the ground also indicate that they frequently fly close to the ground. In addition to that type of flight behavior, the flies also have higher and longer flights.

Table 5. Sandflies collected on oiled tins suspended 1.5 m above ground at Paloich. Sixty tins examined daily from 13 September to 10 October, 1963.

Phlebotomus species	Specimens
orientalis	1
africanus	16
antennatus	7
schwetzi	1
squamipleuris	18
	53

MAN-BITING BEHAVIOR AND WIND EFFECTS

Methods. In conjunction with collecting sandflies for other purposes, data was obtained on the influence of wind on man-biting activity and various aspects of biting behavior. As three to six teams made collections at human lures, counts were made by each in five-minute intervals and recorded at a central point along with wind velocity at corresponding intervals. These and other relevant data were gathered on 36 nights between 20 March and 9 June, 1963. The work was almost entirely confined to Gabek Forest and Old Woods Site. Since the observations were made on live flies, identifications could not be made, but without doubt the majority of specimens were *orientalis*, which is the dominant man-biter in the areas.

Wind was measured by a three-cup anemometer[4] stated to be accurate at a minimum wind velocity of 0.2 m/sec (0.72 kmph). In use, the instrument was placed 1.5 m above ground.

Results. During most nights in which records were kept, the wind velocity was below 1.5 m/sec (5.3 kmph) and had no noticeable effect on sandflies attracted to human lures. Between 1.5 and 2.5 m/sec, the wind had a strong influence on biting activity (fig. 8). During the five nights when wind reached that speed, biting fell off sharply but did not stop completely. When winds were stronger than about 4.0 m/sec (14.5 kmph) flies ceased biting entirely and collecting usually was not attempted.

As noted by Hoogstraal, Dietlein & Heyneman (1962), the number of flies attracted to human lures varies erratically during the evening without apparent reason. Our measurements of flies caught in five-minute intervals also exhibit an erratic periodicity and during all night collecting the numbers taken per interval were as variable as the two examples in fig. 8. There is no evident correlation between wind, temperature and biting activity.

Flies began biting man shortly before darkness at about 1830 hours (Hoogstraal *et al.*, *l.c.*, state 1900). Our collecting generally ceased between 2030 and 2100 when flies were no longer collected in large numbers. The more abundant the flies were the later in the evening they persisted and occasionally good collections were made until 2130 or 2200. Hoogstraal *et al.* (*l.c.*) noted that flies continue to bite throughout the night with an increase at about sunrise (0545) and often bit until full sunlight at 0700.

On adult Africans, sandflies appear to have no preference for any particular part of the body and were found biting on all exposed parts from the feet to

Table 6. Time required for sandflies to feed to repletion; all feedings on author.

Body Site	Time	Body Site	Time
Upper arm	2′25″	Thigh	6′40″
” ”	3′30″	”	6′55″
” ”	7′50″	”	10′40″
Elbow	4′0″	Knee	2′30″
”	4′0″	”	3′10″
”	12′40″	”	5′0″
Forearm	2′30″	”	5′45″
”	3′55″	Lower leg	2′0″
”	5′0″	” ”	2′55″
Hand	2′30″	” ”	3′30″
Thigh	1′45″	” ”	4′15″
”	2′45″	” ”	4′30″
”	3′0″	” ”	5′55″
”	3′15″	” ”	7′50″
”	3′40″	” ”	8′0″
”	5′15″		
		Average	4′45″

4. "Sensitive Anemometer" manufactured by Casella & Co., Ltd. London; sold by Science Assoc., Inc. 194 Nassau St., Box 216, Princeton, N. J.

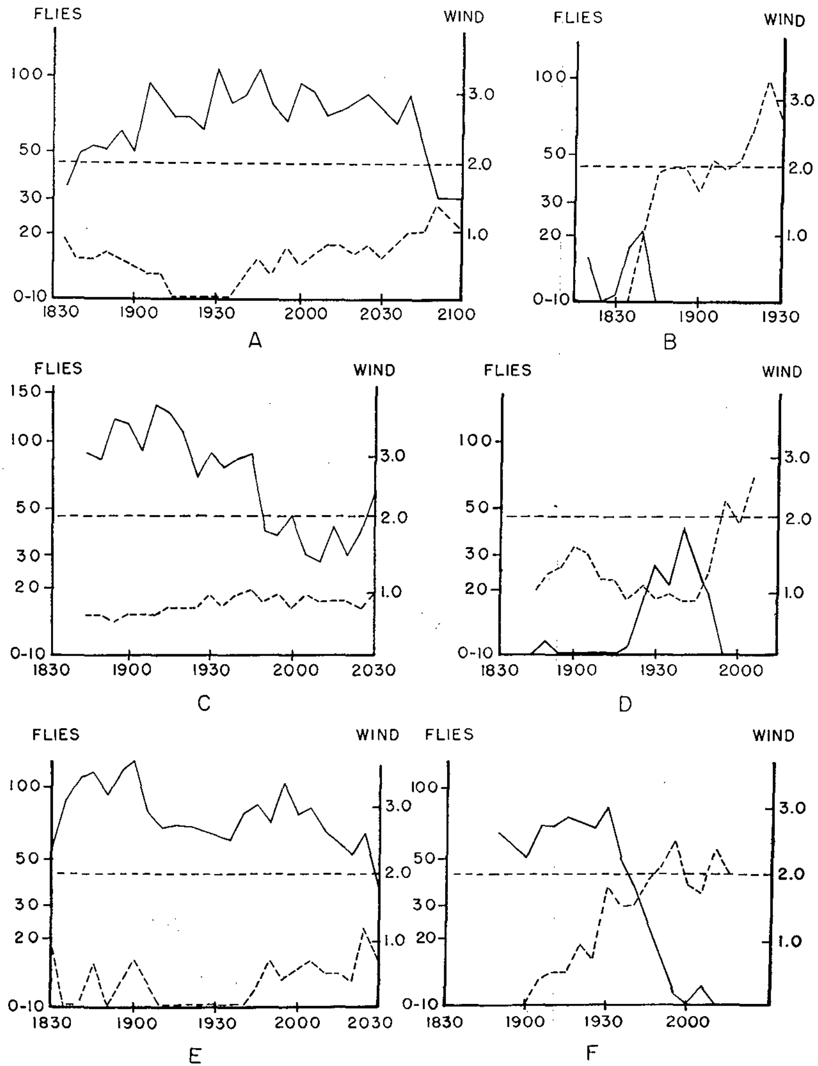

Fig. 8. Number of sandflies attracted to human lures (solid lines) and wind velocity in m/sec (broken lines) at five-minute intervals. A. Gabek Forest, 10 April; B. Pador Village, 20 May; C. Gabek Forest, 1 May; D. same, 11 April; E. same, 25 April; F. same, 13 May; all 1963.

the face, except the hair. On the other hand, boys of about 10–14 years were sometimes most heavily bitten on the head among the hair, and the head was almost the only place flies were collected on some youngsters.

The time required to feed to repletion was determined by timing flies as they fed on myself. In 31 observations (Table 6) repletion was obtained on legs and arms after 1 min 45 sec to 12 min 40 sec with an average of 4 min 35 sec. Sharp pain was felt during about the first 30 seconds while the proboscis was being inserted, but during the actual feeding there was little discomfort. The irritation ceased immediately or persisted only a few minutes after the fly withdrew.

Table 7. Feeding records of *Phlebotomus* species. Hosts in wooden cage with sandflies overnight.

Phlebotomus spp.	Host	% Flies Fed	Total Flies[1]	Trials
orientalis	Gecko, *Hemidactylus turicus*	0	14	2
,,	Skink, *Mabuya striata*	3	92	6
,,	Lizard, CMNH HH-9283[2]	1	99	3
,,	Lizard, CMNH HH-9284[2]	0	32	1
,,	Shrew, *Crocidura s. sericea*	0	8	1
,,	Rat, *Rattus* sp.	11	18	1
,,	Rat, *Arvicanthus niloticus luctuosus*	14	57	5
,,	Rat, *Mastomys natalensis ismailiae*	0	180	2
heischi	Gecko, *H. turicus*	0	1	1
,,	Skink, *M. striata*	50	2	1
,,	Lizard, CMNH HH-9283[2]	100	4	1
,,	Lizard, CMNH HH-9284[2]	100	1	1
,,	Shrew, *C. s. sericea*	0	1	1
,,	Rat, *A. niloticus luctuosus*	63	8	2
clydei	Lizard, CMNH HH-9283[2]	100	1	1
,,	Lizard, CMNH HH-9284[2]	0	2	1
,,	Rat, *Mastomys* (?)	100	1	1
,,	Rat, *A. niloticus luctuosus*	95	20	1
adleri	Hamster, *Cricetus auratus*	0	1	1
africanus	Toad, *Bufo regularis* (?)	0	18	2
,,	Gecko, *H. turicus*	83	69	5
,,	Skink, *M. striata*	69	26	3
,,	Puff adder	72	36	2
,,	Snake, CMNH HH-9111[2]	83	98	4
,,	Snake, CMNH HH-9112[2]	45	44	5
,,	Hedgehog, *Atelerix p. pruneri*	0	6	1
,,	Shrew, *C. s. sericea*	0	20	2
,,	Rat, *A. niloticus luctuosus*	0	4	1
,,	Spiney mouse, *Acomys albigena*	25(?)	8	2
,,	White mouse	0	13	1
,,	Hamster, *C. auratus*	0	12	1
antennatus	Gecko, *H. turicus*	100	1	1
,,	Skink, *M. striata*	100	1	1
,,	Puff Adder	0	2	1
,,	Snake, CMNH HH-9111[2]	40	5	2
,,	Shrew, *C. s. sericea*	0	1	1
,,	White mouse	0	13	1
,,	Hamster	0	1	1
bedfordi	Puff Adder	100	1	1
schwetzi	Toad, *Bufo regularis* (?)	100	1	1
,,	Lizard, CMNH HH-9283[2]	0	1	1
,,	Snake, CMNH HH-9112[2]	100	1	1
squamipleuris	Toad, *Bufo regularis* (?)	85	20	1
,,	Skink, *M. striata*	9	22	1
,,	Puff Adder	23	16	1

[1] Live flies removed from cages at end of experiments.
[2] Identifications not yet received from Chicago Museum of Natural History.

Table 8. Sandfly species of the Paloich area and known hosts.

Phlebotomus spp.	Hosts	*Phlebotomus* spp.	Hosts
orientalis	Skink	*adleri*	Man (?)
	Lizard	*africanus*	Gecko
	Rodent		Skink
	Man		Snake
papatasi	Gecko		Rodent (?)
	Skink		Man
	Rodent	*antennatus*	Gecko
	Guinea Pig		Skink
	Dog		Snake
	Monkey	*bedfordi*	Skink
	Man		Snake
heischi	Lizard		Man
	Rodent	*schwetzi*	Toad
	Man		Snake
clydei	Gecko		Fowl
	Skink		Bat
	Ground Squirrel		Rabbit
	Gerbils		Man
	Hamster	*squamipleuris*	Toad
	Rodent		Gecko
	Dog		Skink
	Monkey		Snake
	Man		

Sensitivity to bites varies with individuals and irritation to some people may last several days after having been subjected to massive biting (Hoogstraal *et al.*, *l.c.*).

SANDFLY HOSTS

Methods and materials. Various small vertebrates were exposed to wild-caught sandflies and subsequently examined for feeding results to increase the information about animals which are acceptable hosts of sandflies.[5] Hosts and sandflies were confined together in cages. After one night's exposure, the flies were removed and fed females separated from unfed. At first the host animals were left free in the cage, but they ate a large number of the flies and later the animals were confined in a cylindrical, wire mesh cage without altering feeding results, but reducing the loss of flies.

Additional feeding records were obtained from Dr. Bruce McMillan in conjunction with his work on lizard leishmaniasis at Malakal. Identifications of fed flies obtained by McMillan were made by me. Mrs M.L. Schmidt also obtained feeding records on gecko by *papatasi* in Cairo from lab-reared specimens. Both used essentially the method described above.

Results and discussion. The results of feeding tests are given in Table 7; a compilation of host records from this and other works is given in Tables 8 & 9.

Host groups of *Phlebotomus* correspond approximately with taxonomic divisions. Species of the subgenus *Phlebotomus* feed mainly on mammals and those of *Sergentomyia* on cold-blooded vertebrates, as was pointed out 30 years ago by Parrot (1934). *P.* (*P.*) *orientalis*, *papatasi* and *heischi* are the three Upper Nile species which most commonly bite man and several authors record other mammal hosts for them (Table 9). *P.* (*Sergentomyia*) *africanus*, *antennatus*, *bedfordi* and *squamipleuris* chiefly feed on cold-blooded animals. There is much overlapping of host and sandfly groups, however, and the correspondence of the two is far from exact. The three species of the subgenus *Phlebotomus* will feed on reptiles, but mammals are undoubtedly their preferred hosts. In *Sergentomyia* there seems less crossing over to mammal hosts, but it does happen.

P. clydei and *schwetzi* are intermediate in host selection to the two groups above. Dr McMillan's work (unpublished) clearly shows that *clydei* readily feeds on lizards and the man-biting records from NAMRU-3 and other workers (see Kirk & Lewis 1940) demonstrate the suitability of mammal hosts for this species. *P. schwetzi* also has no difficulty in feeding on either cold or warm-blooded animals, but in the Paloich area it seems to feed less on man than does *clydei*. Table 10 compares the man-biting rate and abundance of these two species with *orientalis*.

5. Female sandflies only feed on blood; males do not at all or only feed on plant liquids.

Table 9. Vertebrate host of sandflies in Paloich area. (Uncited records obtained by Dr McMillan or author.)

Host	*Phlebotomus* spp.	Authority
Toad, *Bufo regularis* (?)	*schwetzi*	
	squamipleuris	
Gecko, *Hemidactylus turicus*	*clydei*	
	africanus	
	antennatus	
	squamipleuris	
Gecko, *H.* sp.	*papatasi*	M. L. Schmidt (pers. comm.)
Skink, *Mabuya striata*	*orientalis*	
	heischi	
	clydei	
	africanus	
	antennatus	
	bedfordi	
	squamipleuris	
Skink, *M. varia*	*clydei*	
	africanus	
	antennatus	
	bedfordi	
	squamipleuris	
Skink, CMNH HH-9122[1]	*clydei*	
	africanus	
	antennatus	
	squamipleuris	
Skink, *M.* sp.	*papatasi*	M. L. Schmidt (pers. comm.)
Lizard, CMNH HH-9283[1]	*orientalis*	
	heischi	
	clydei	
Lizard, CMNH HH-9284[1]	*heischi*	
Puff Adder	*africanus*	
	bedfordi	
	squamipleuris	
Snake, CMNH HH-9111[1]	*africanus*	
	antennatus	
Snake, CMNH HH-9112[1]	*africanus*	
	schwetzi	
Gerbils	*clydei*	Heisch *et al.* 1956
Fowl	*schwetzi*	Wanson, 1942
Bat	*schwetzi*	Kirk & Lewis, 1951
Rabbit	*schwetzi*	Wanson, 1942
Ground Squirrel	*clydei*	Kirk & Lewis, 1951
Hamster	*clydei*	Kirk & Lewis, 1951
Guinea Pig	*papatasi*	Auctt.
Rodents	*papatasi*	Kirk & Lewis, 1951
Rat, *Rattus* sp.	*orientalis*	
	clydei	
Rat, *Arvicanthus niloticus luctuosus*	*orientalis*	
	heischi	
	clydei	
Spiney Mouse, *Acomys albigena*	*africanus* (?)	
Dog	*papatasi*	Kirk & Lewis, 1951
	clydei	" " " "
Monkey	*papatasi*	" " " "
	clydei	" " " "
Man	*orientalis*	
	papatasi	
	heischi	

[1] Identification not yet received from Chicago Museum of Natural History.

Table 9. (Continued)

Host	*Phlebotomus* spp.	Authority
Man	*clydei*	
	adleri (?)	Heisch *et al*, 1956
	africanus	Hoogstraal *et al*, 1962
	bedfordi	
	schwetzi	

Table 10. Man-biting and oiled paper collections from forested localities in the Paloich area, 1963

Phlebotomus Species	February % Btg.	February % OP	February No. of Spec.	March % Btg.	March % OP	March No. of Spec.	April % Btg.	April % OP	April No. of Spec.	May % Btg.	May % OP	May No. of Spec.
orientalis	98	1	(338)	94	41	(1541)	99	56	(5245)	98	17	(297)
clydei	2	79	(713)	4	34	(657)	0	12	(301)	0	25	(87)
schwetzi	0	20	(174)	2	25	(482)	1	32	(796)	2	58	(208)

(Note that oiled paper records for February are probably low for *orientalis*, since castor oil had not yet been replaced by seasame oil; see methods p. 222.) The figures indicate that a far smaller proportion of *clydei* and *schwetzi* than of *orientalis* feed on man. Other hosts must be more attractive to them; whether these are cold or warm-blooded is not known.

Unidentified sandflies have been reported feeding on a moth (Kirk & Lewis 1951). This unusual and interesting record has never been confirmed by other observations, but perhaps there are sandflies, as among the bloodsucking Ceratopogonidae, which feed on invertebrates.

RESTING SITES AND DAILY ACTIVITY

The deeply cracked, fissured bark and cavities of *Balanites* trees are the daytime resting sites of many adult sandflies during the wet season. Flies could be found on trees scattered throughout the forest, in trees of villages and even in isolated trees in the grasslands. The smoothbarked *Acacia* trees have few recessed, protected places and flies were not found on them, except in holes formed by decay or wood-boring beetles in dead or dying trees.

As the dry season advances, tree trunks become less suitable resting sites. During November, a month after the end of the rains, flies were still fairly abundant there. By December, their numbers were decreasing and in January they were quite rare in these niches. From February through the rest of the dry months, sandflies were difficult to find on tree trunks during the day, although numerous in other kinds of collections. As the weather was hotter and less humid than during the rains, it is assumed that sandflies seek cooler and more humid places in the heat of the day.

Adults were again found on trees by the middle of May 1963 after several heavy rains had fallen and the soil was wet or moist to a level of 34 cm (in Gabek Forest at least). From then until collecting stopped in September, sandflies could be found in hiding places on the trees.

During the dry season the subsurface cavities appear to be the main, if not only, daytime resting sites of sandflies. Shrinkage cracks extend to depths of at least a meter to the line of visible moisture. These subterranean habitats are cooler and moister than above ground sites and offer a refuge from the heat and dessication of those places. Subterranean cavities during the dry season generally result from two causes, shrinkage of the soil and rodents. While some rodents utilize the shrinkage cracks for burrows, others (*Acomys*) excavate burrows in friable soil which does not form large cracks when dry.

Collections of sandflies were made by placing oiled papers over cracks and burrows and recording only those on the undersurface. Papers set out in the evening were usually examined the following morning. Flies caught in this manner were never numerous in studies and seldom were there more than two or three flies per paper and the same held with rodent burrows. A few flies were observed when digging for soil samples, but never in large concentrations. Nothing indicated that sandflies were more numerous in or around rodent burrows than in other subsurface sites. The flies do not seem to congregate in particular spots, but spread over wide areas. However, there may be concentrations of adults at the breeding sites, which were never found.

During the rains most of the subsurface openings disappear as the soil expands with absorbed water. However, they do not disappear suddenly nor are they entirely absent in the rains. Well drained ground dries quickly and a few hot, rainless days will produce cracks and shrinkage holes down to 25 cm before the time when the soil is thoroughly saturated. It is probably not until July or August in most years that

subterranean cavities are completely unavailable as daytime resting sites for sandflies. As noted, it is well before this that tree cavities harbor sandflies in the daytime. Even the seasonal species, *orientalis*, *clydei* and *schwetzi*, have been found on tree trunks in small numbers. Kirk & Lewis (1951) suggest that the disappearance of the subsurface resting (and feeding) sites may explain the seasonal periodicity of sandflies. It does not seem that the adult populations would be seriously affected in this way, for the subterranean cavities would not be entirely absent by the time the seasonal species have diminished sharply, and furthermore, when the weather is cooler and more humid tree cavities would seem to offer satisfactory resting places.

In the dry season there is little foliage in the forest, except on two evergreens *Boscia senegalensis* and *Capparis* sp. Visual observations and oiled paper catches show that sandflies gather here at night in high numbers and copulation by *orientalis* was also observed in the foliage of *Boscia*. These evergreens apparently are attractive as nighttime resting sites. It would not seem likely that feeding occurs here, for no animals were seen, although it is possible that nocturnal geckoes were present and overlooked. In the forests, spraying the evergreens with a residual insecticide might offer a feasible control measure for adult sandflies if control were deemed most effective by eliminating adults.

The insides of tukls offer protected, dark resting spots in the grass roofs and cracks of the mud walls. A few sandflies were found on the walls during the day and night, but searches were not made of the roof and wall holes. Oiled paper catches indicated sandflies were often present in tukls and in addition to feeding, the flies probably rest here.

The nocturnal habits of *Phlebotomus* are too well known to require substantiation. However, the flies are not exclusively nocturnal and there is a limited amount of diurnal activity. Kirk & Lewis (1951) cited several examples and it was also noted in some of the Paloich species. Two small Malaise traps were examined twice daily during two months (Table 11)

Table 11. Malaise trap catches during 28 trapping days in August and September 1962 at Paloich compound.

Phlebotomus species	Specimens 0800—1800	Specimens 1800—0800
africanus	11	61
antennatus	0	1
squamipleuris	16	41
orientalis	1	1
papatasi	1	0
	29	108

and the catches showed that some flies were moving in the day. Only active flies could have found their way into the catching cylinders, since they were about a meter from the ground. The period when the specimens were captured had many cool, cloudy and rainy days, which may have contributed to the diurnal activity. Similar studies were not repeated in the hot, dry season. No man-biting was noted other than from dusk to dawn.

BREEDING SITES

Methods and materials. Soil samples suspected of having immature stages of sandflies were examined directly and by a sugar solution flotation technique described by Hanson (1961). The procedure consists of mixing the soil with a saturated sugar solution (3 parts sugar to 5 parts water) in which larvae and pupae float. After a thorough mixing the heavier soil particles sink and the lighter, floatable materials rise to the surface. The latter fraction contains the immature stages and is separated by washing through a series of sieves, after which the residues are examined under a dissecting microscope.

The efficacy of the method was demonstrated by Hanson (*l.c.*) who found more than 2000 larvae of 15 *Phlebotomus* species in Panama. The method was also tested by us with soil samples containing lab-reared *papatasi* larvae and more than 75% were recovered from two seeded samples.

Each of the samples contained about two liters of soil weighing from 2–3 kg. The material was examined a few hours after collection. Soil was taken from all places which conceivably might harbor immature stages of sandflies (Table 12). In the dry season samples were taken to a depth of 1.2 m which is below the visible moisture line and below the depths to which the conspicuous cracks extend. Nearly all the samples from forests were collected in Gabek Forest and Old Woods Site where *orientalis* was most abundant.

Particular attention was given to rodent burrows. Soil cracks were also excavated for many samples, because oiled papers consistently showed the presence of adults and King (1913, 1914) found immature stages in these situations in N.E. Sudan. Soil from tree bases was also searched carefully because of the abundance of adults on tree trunks in the wet season.

In the villages samples were taken from under manure heaps and the central clearing where animals are tethered during the day and which receive livestock feces and urine. The floors of animal tukls were also examined, but not as extensively as desired because villagers were reluctant to have soil taken from the shelters.

Other places, as grass and dirt from tree holes, ter-

mite and ants nests and cracks in the banks of a hafir, received our attention. Ground cover was not searched, since in the dry season it is extremely dry and sparse and during the rains there is little organic litter on the ground.

Results. Only a single larva of *P. africanus* was found in 2000 kg of soil. It was in mud at the base of a tree in Remajiy village. Within a week before finding it the ground had been under several cm of standing water. Many other searches were made in this and similar spots without success and the larva's presence in the mud was apparently an abnormal phenomenon.

The absence of larvae or pupae from such a wide variety of samples is difficult to explain. It does not seem probable that the sugar flotation is faulty because of the high recovery rate of larvae from seeded samples. Also, the larvae of many other insects, as nematocerous and muscoid Diptera, Siphonaptera, Lepidoptera and Coleoptera, were recovered along with Collembola, immature myriapods, pseudoscorpions, ticks, mites and small annelids. The breeding sites of *Phlebotomus* in the Paloich area must be highly localized. Only further work will reveal the conditions necessary for oviposition and development of sandflies in the Upper Nile Province.

Table 12. Soil samples examined for immature stages of *Phlebotomus* in the Paloich area.

Source of samples	Number of samples
Soil cracks in forests	138
Tree bases in forests	51
Rodent burrows	266
Tree bases in villages	151
Village centers and margins, including manure heaps	134
Floors of animal tukls	36
Embankment of hafir	36
Tree holes	11
Termite nests	47
Ant nests	4
Total samples	874
Approximate kg soil	2185

Part II. Taxonomy

To facilitate identifications of *Phlebotomus* species by others working in the Paloich area, or similar kala-azar locales, a detailed taxonomic coverage of the species has been prepared. Although restricted to a local area because of limitations imposed by the author's work, it may well prove to be useful over a wider area, since the same general type of mixed open and forested savannah extends the width of Africa and the species within this extensive area may not differ greatly from those found in the Paloich area.

Keys to species and descriptions, illustrations and distributions of each are given. Synonymical bibliographies are believed to include all references pertinent to the taxonomy or nomenclature based on African specimens, but is not intended to be complete for widespread species.

The classification adopted here is based on two considerations. First, it has been attempted to make the classification of phlebotomines consistent with that used in the rest of the family Psychodidae, of which *Phlebotomus* is only a part. Second, the author feels that taxonomists have an obligation to be conservative when working with a group that is of medical importance and of interest to a broad group of scientists. Nomenclatorial changes should be kept at a minimum and this can best be achieved by using taxa in their broadest senses until taxonomic studies are complete enough to assure widespread acceptance of suggested changes. From these viewpoints, the division of the Old World *Phlebotomus* into two genera, with the concomitant elevation of subgeneric groups (Theodor 1948, 1958), is not acceptable.

Many species of *Phlebotomus* exhibit some variation of important taxonomic characters. This has led to a proliferation of names, which were proposed for these variants. The older term " variety " no longer is accorded formal nomenclatorial recognition and is seldom used. Some of the varieties undoubtedly are subspecies, the only infrasubspecific category formally named, but it is the responsibility of the author to prove this before indiscriminately elevating an older varietal name to subspecies. Subspecies is clearly defined as consisting of populations which are geographically or ecologically separated from other populations of the same species and these segregates are differentiated, except in zone of overlap, by consistent taxonomic features.

In the long series of most species in the Paloich area, the author has found many of the varieties named by earlier workers. The assumption is made that all specimens of this limited area belong to interbreeding populations of their respective species. There is nothing to indicate there are geographical or ecological barriers to gene flow within any of the species in the area. It is therefore concluded that the variation exhibited by the Paloich populations is at the level of the individual, i.e., individual variation, and may fall within the variation range of any population of that species. None of the forms encountered merit elevation to subspecific rank and where my evidence supports it, I have relegated named varieties to synonymy with their nominate species.

A description of morphological terms important to the taxonomy of *Phlebotomus* was given by Kirk &

Lewis (1951). That will not be repeated here, but the terminology has been changed in some cases to conform to a broader usage. "Cibarium" is used in place of "buccal cavity." Two types of teeth are often present in the cibarium. The larger ones are "horizontal teeth" or simply "teeth" and the smaller ones, which appear as mere dots below the large teeth, are termed "erect teeth."

The specialized terms applied to the wing venation in *Phlebotomus* are rejected entirely. There are available terms for the same veins used throughout the insects and one genus does not seem to warrant its own special terminology. Thus, R_2 replaces "alpha" and R_{2+3} replaces "beta." R_1 tip or "overlap" is sufficient to describe the ending of R_1 previously termed "delta." Specialized terms or symbols, as "alar index", "AIII/E," and "antennal formula" are replaced by descriptions.

"Palpal ratio" is used in a different sense than by Kirk & Lewis (*l.c.*) and refers to the relative lengths of the 1st and 2nd palpal segments combined, the 3rd, 4th, and 5th. The division between the partly fused first and second segments makes exact measurement difficult and probably inconsistent and a more accurate measurement is obtained by combining the two. "Palpal formula" is used as described by Kirk & Lewis and is the number of each segment in the order of increasing length. There is usually enough difference in length between the second and other segments that the inaccuracy of its measurement doesn't affect its order in the formula, although it should be remembered that in cases where the second does not differ greatly from another segment, some inconsistencies may arise from being unable to measure the segment precisely.

Certain structures of the male genitalia differ from those used by Kirk & Lewis (*l.c.*). The terms "dististyle," "basistyle," "aedeagus," and "surstyle" are used in place of "style," "coxite," "penis sheath," and "lateral lobe," respectively.

Museums which are the depositories of type specimens are abbreviated as follows: British Museum (Nat. Hist.), London—BMNH; Institut Pasteur d'Algerie—IPA.

The scale lines in the illustration represent 0.1 mm, except those for the wings which represent 0.5 mm.

Key to Phlebotomus species of the Paloich Area

Females

1. Cibarium without row of teeth; palpal segment 4 conspicuously shorter than 3; tergites 2–6 with many erect hairs, i.e. hair sockets as large as those on tergite 1 .... Subgenus **Phlebotomus**. . 2
   Cibarium with row of teeth; palpal segment 4 longer than or but little shorter than 3; tergites 2–6 without erect hairs or with only band on posterior margin, i.e., sockets smaller than on tergite 1 .... Subgenus **Sergentomyia**. . 6
2. Pharynx lightly pigmented in center; spermatheca distinctly segmented 3
   Pharynx deeply pigmented in center; spermatheca unsegmented 4
3. Antennal ascoids on segment 4 short, not extending far beyond center of segment, usually 0.3 length of segment; antennal segment 3 longer than 4+5 combined; pharyngeal armature spinose, giving distal part of pharynx a darkened appearance; spermatheca with long apical extension bearing apical knob, extension about 0.5 length of body ..... **langeroni orientalis**
   Antennal ascoids longer, extending well beyond center, usually 0.5 length of segment; antennal segments 3 and 4+5 combined subequal; pharyngeal armature consisting of blunt-pointed folds; spermatheca without apical extension .... **papatasi**
4. Antennal segment 3 shorter, not extending beyond tip of palpal segment 2; chitinous arch extending forward in broad, median extension; spermatheca large, sac-like, duct very short 5
   Antennal segment 3 extending beyond tip of palpal segment 2; chitinous arch not extending forward on midline; spermatheca slender, duct very long, coiled several times within body .... **rodhaini**
5. Ascoids of antennal segment 4 long, extending nearly to tip of segment .... **heischi**
   Ascoids very short, scarcely exceeding center of segment .... **lesleyae**
6. Walls of cibarium smooth below teeth, teeth not arranged in convex row; spermatheca without bands of setae; Newstead scales only on palpal segment 3 7
   Walls of cibarium projecting inwards in large, coarse expansions, teeth numerous, in crown-like, convex row; spermatheca with bands of setae; few Newstead scales on palpal segment 2 as well as larger patch on segment 3 .... **squamipleuris**
7. Pharynx unarmed distally or only with few, small spines; pigment patch not dark enough to obscure teeth 8
   Pharynx heavily armed distally with numerous, dark spines; pigment patch very dark,

often obscuring teeth unless specimen well cleared 11

8. Cibarium with row of spike-like teeth, all of which clearly project posteriorly beyond pigment patch; palpal segment 4 shorter than 3; spermatheca ovoid, clearly segmented .. 9

Cibarial teeth not in spike-like row, none or only central teeth project posteriorly beyond pigment patch; palpal segment 4 subequal to or longer than 3; spermatheca unsegmented 10

9. Cibarium with 1 complete and sometimes partial 2nd row of erect teeth .... **clydei**

Cibarium with 3–5 rows of erect teeth .. **adleri**

10. Cibarial teeth slender, numerous, in comb-like row; apex of pharynx with few spines; spermatheca in shape of capsule clearly differentiated from slender duct .... **africanus**

Cibarial teeth broad at base and suddenly constricted to acute apices, lying at angle directed downward and inward, median teeth smaller than lateral ones; pharynx only with wrinkles and fine setae apically; spermatheca hardly differentiated from broad duct .... **schwetzi**

11. Pharynx without indentations on sides; palpal segment 4 equal to or little longer than 3 .... **antennatus**

Pharynx indented on sides; palpal segment 4 clearly longer than 3 .... **bedfordi**

Males

1. Tergites 2–6 largely covered with erect hairs, i.e., sockets as large as those on tergite 1; dististyle of genitalia with 4 or 5 spines, at least 1 of which well before apex .... Subgenus **Phlebotomus** .. 2

Tergites 2–6 with recumbent hair only, i.e., small sockets, sometimes with few erect hairs along posterior margin; dististyle with 4 apical spines only, except *schwetzi* which has 2 apical and 2 at distal 3/4 unlike any of above species .... Subgenus **Sergentomyia** .. 7

2. Dististyle with 5 spines; genital pump small and located posteriorly in segments 6 or 7 3

Dististyle with 4 large spines, 3 of which central; genital pump large and located in segments 5 or 6, filaments very long .... **rodhaini**

3. Dististyle with at least 1 spine near center; basistyle without tuft of hairs near base; paramere without curved, slender, dorsal projection 4

Dististyle with all spines clearly distad of center; basistyle with tubercle bearing tuft of hairs near base of inner face; paramere trilobed, upper lobe a curved, slender, dorsal projection 6

4. Paramere of genitalia a complex, multilobed structure 5

Paramere a simple, unbranched structure .... **langeroni orientalis**

5. Ascoids on antennal segment 4 more than 1/2 length of that segment; paramere bilobed, lower lobe with 4 or 5 black, conspicuous spines .... **heischi**

Ascoids short, less than 1/2 of segment 3; paramere trilobed, without black spines, inner lobe thin, plate-like ..... **lesleyae**

6. Upper lobe of paramere long, extending well beyond tips of other lobes; surstyle with only 2 spatulate spines at tip .. **papatasi**

Upper lobe of paramere short, not extending beyond tips of other lobes; surstyle with about 5 spatulate spines at tip .... **duboscqi**

7. Dististyle with all spines apical or subapical 8

Dististyle with 2 spines apical and 2 at distal 3/4; adeagus large, curved, apex rounded; basistyle with many non-deciduous hairs .... **schwetzi**

8. Wall of cibarium straight and unexpanded below teeth 9

Wall of cibarium projecting inwards in coarse expansion below teeth; paramere ending in blunt, beak-like tip; tip of genital filament inflated; dark colored species .... **squamipleuris**

9. Aedeagus ending in rounded, blunt tip 10

Aedeagus tapering to sharp point 11

10. Palpal segment 4 equal to or but little longer than 3 .... **antennatus**

Palpal segment 4 clearly longer than 3 .. **bedfordi**

11. Antennal segment 3 shorter than epipharynx; basistyle with few nondeciduous hairs 12

Antennal segment 3 longer than epipharynx; basistyle with many nondeciduous hairs .... **africanus**

12. Cibarium with single, rarely 2 rows of erect teeth; tergite 6 considerably larger than 5 .... **clydei**

Cibarium usually with more than 2 rows of erect teeth; tergites 5 and 6 subequal .... **adleri**

Genus **Phlebotomus** Rondani

Flebotomus Rondani, 1840, Mem. Prima Serv. Dipt. Ital., p. 12.

Type species: *Phlebotomus papatasi* (Scopoli), by monotypy.

Subgenus **Phlebotomus** Rondani

Phlebotomus (*Phlebotomus*): França & Parrot, 1920, Bull. Soc. Path. Exot. **13**: 699; 1921, Arch. Inst. Pasteur Afriq. Nord, **1**: 283. Parrot, 1934, Arch. Inst. Pasteur Alg. **12**: 389. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 37. Theodor, 1948, Bull. Ent. Res. **39**: 96. Kirk & Lewis, 1951, Trans. R. Ent. Soc. London, **102**: 412. Parrot, 1951, Arch. Inst. Pasteur Alg. **29**: 31. Theodor, 1958, Flieg. Pal. Reg., Lief. 201, p. 16.

Cibarium without well developed row of horizontal teeth, usually with fine spicules on margins and few, scattered, setiform teeth anteriorly; pigment patch lacking or faint. Antennal segment 3 usually long. Palpal segment 4 shorter than 3, often shorter than 2. R_{2+3} usually shorter than R_2. Abdomen with numerous erect hairs (recognized in mounted specimens by sockets as large as on tergite 1) on tergites 2–6. ♂ genitalia: Dististyle, with 3–5 spines, only 1 or 2 terminal, others well removed from apex; paramere often a complicated, multilobed structure. Species generally large and paler colored compared to those of *Sergentomyia*.

Phlebotomus (Phlebotomus) langeroni orientalis Parrot Fig. 9.

Phlebotomus langeroni var. *orientalis* Parrot, 1936, Arch. Inst. Pasteur Alg. **14**: 30. Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 627; 1946a, Ann. Trop. Med. Parasit. **40**: 39.

Phlebotomus (*Larroussius*) *langeroni orientalis*: Theodor, 1958, Flieg. Pal. Reg., Lief. 201, p. 24. Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 594.

Phlebotomus orientalis: Parrot & Clastrier, 1946, Arch. Inst. Pasteur Alg. **24**: 62.

Phlebotomus (*Phlebotomus*) *orientalis*: Kirk & Lewis, 1948, Ann. Trop. Med. Parasit. **42**: 326; 1951, Trans. R. Ent. Soc. London, **102**: 432; 1952, Ann. Trop. Med. Parasit. **46**: 340. Heisch, Guggisberg and Teesdale, 1956, Trans. R. Soc. Trop. Med. Hyg. **50**: 212. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 634.

Large species, metanotum brownish, pleuron and coxae pale colored; pharynx of ♀ lightly pigmented, with apical spinose area darkened.

♀. Cibarium (fig. 9e) with numerous spicules laterally and few, scattered setiform teeth anteriorly; pigment patch absent; chitinous arch well developed. Pharynx (fig. 9e) lightly pigmented centrally, maximum width about twice minimum, distally with small spines in close-set rows, when spines upright, rows may appear crenulated when bases of spines seen in cross section, spinose area darkened, few setose ridges below and above spines. Epipharynx subequal to length of antennal segment 3. Antenna (fig. 9a) with segment 3 longer than 4+5 combined, extending to distal 1/4 of tip of palpal segment 2; ascoids (fig. 9c) paired on segments 3–15, usually 0.3 length of segment 4. Palpal formula usually 1–(2–4)–3–5, segment 2 may be little longer or shorter than 4, average ratio= 24: 20: 17: 40; segment 3 with large patch of Newstead scales at basal 1/3. Wing (fig. 9g) with R_{2+3} 0.5—0.6 length of R_2, R_1 apex 0.2–0.4 length of R_2. Spermatheca (fig. 9j) with 11–15 well defined segments, apical knob sparsely setose, at end of long, slender extension, extension about 1/2 length of spermatheca body.

Measurements: Antenna 3=0.27±0.02 mm (0.22–0.32); 4+5=0.22±0.01 mm (0.20–0.26). Epipharynx =0.27±0.01 mm (0.24–0.31). Wing length=2.16± 0.15 mm (1.82–2.48); width=0.60±0.05 mm (0.51–0.74). 50 specimens.

♂. Cibarium (fig. 9f) similar to ♀ but smaller. Pharynx (fig. 9f) smaller than ♀, but with similar distal armature. Epipharynx shorter than antennal segment 3, 0.7–0.8× length of that segment. Antenna (fig. 9b) with segments 3, 4, 5 longer than in ♀, 3 extending beyond tip of palpal segment 2; ascoids (fig. 9d) paired on segments 3–6 or 7, remainder single, short, 0.19–0.26 length of 4. Average palpal ratio=19: 16: 14: 34. Genitalia (fig. 9h): Dististyle with 5 long spines, 2 of which apical, 2 at distal 1/3 and 1 near center; basistyle with few nondeciduous hairs, without setiferous tubercle; paramere simple, unbranched; aedeagus (fig. 9i) elongate, slender, tapering to recurved apex; genital filaments 2.5–3× pump length.

Measurements: Antenna 3=0.29±0.02 mm (0.25–0.34); 4+5=0.27±0.01 mm (0.24–0.30). Epipharynx =0.21±0.01 (0.18–0.23). Wing length=1.94±0.08 mm (1.71–2.06); width=0.51±0.07 mm (0.42–0.58). 50 specimens.

Types: Diredawa (Diré-Daoua), Ethiopia; IPA.

Distribution: Sudan, Ethiopia, Kenya, Saudi Arabia.

Sudan: Kassala, Darfur, Kordofan, Blue Nile, Upper Nile Provinces.

The ♂♂ of *orientalis* should not be confused with any other species in the Paloich area, as the genitalia are dissimilar to those of other species. The ♀ spermathecae are also distinctive. On the basis of the head, *orientalis* is distinguished from other related species, except *papatasi* and *duboscqi*, by the long, rather slender pharynx lacking deep pigmentation. The darkened spinose area of the pharynx, the short antennal ascoids, and antennal segment 3 being longer

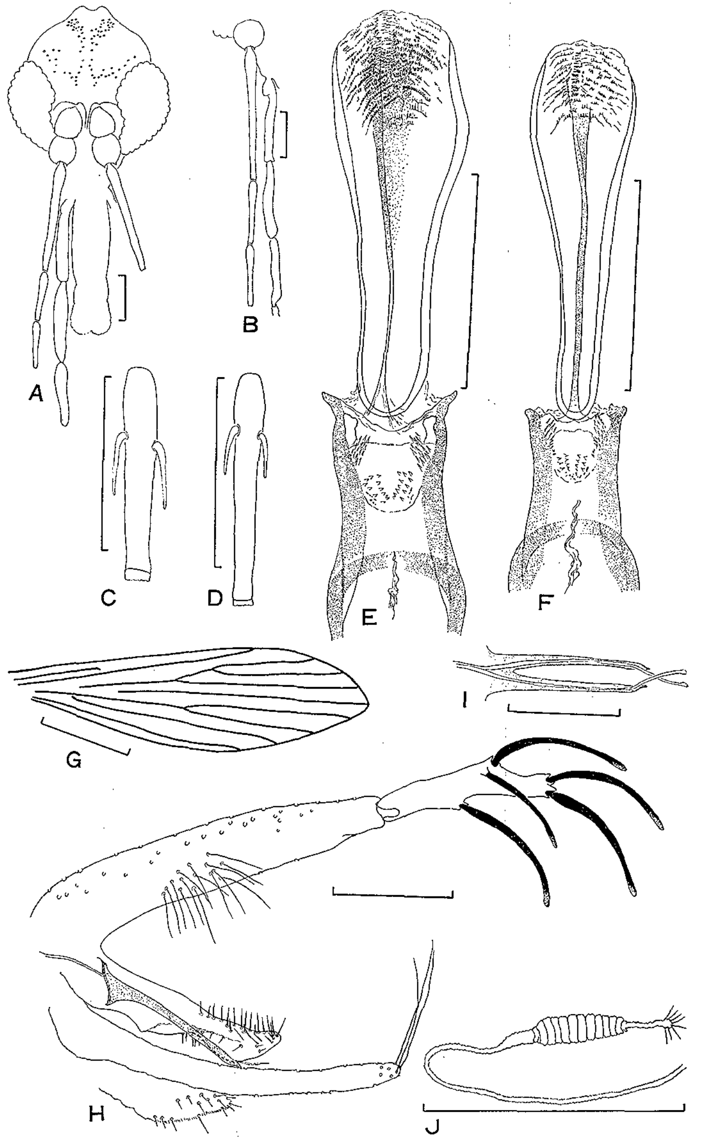

Fig. 9. *Phlebotomus l. orientalis*. a, ♀ head; b, ♂ antenna base and palp; c, ♀ 4th antennal segment; d, ♂ 4th antennal segment; e, ♀ cibarium and pharynx; f, ♂ cibarium and pharynx; g, ♀ wing; h, ♂ genitalia, lateral view; i, ♂ aedeagus, dorsal view; j, ♀ spermatheca.

than, rather than subequal to, 4+5 combined distinguishes *orientalis* from *papatasi* and *duboscqi* when head characters alone are available.

As noted by Parrot & Clastrier (1946), *langeroni* and *orientalis* differ in these respects:

	langeroni	*orientalis*
ascoids	paired on segs. 3–12 or 13	paired on segs. 3–6 or 7
ascoids/seg. 4	0.33	0.19–0.26
wing	Radial and medial forks on same level.	Radial basad of medial
aedeagus tip	curves inward	curves outward
paramere tip	evenly rounded	dorsum slightly attenuate

Seventy ♂♂ of *orientalis* from Paloich (June 1962, March, April 1963) show little variation in the abcve features. 87% have ascoids paired to segment 7 and the rest only to segment 6. The radial fork is usually basad of the medial, but in 13% the forks are on the same level. The aedeagus and paramere are usually as illustrated, but 3% have atypical aedeagi and 5% atypical parameres; none were like *langeroni*. (Some or all of this variation may be due to distortion produced by position on the slide.)

I rely on the description of *langeroni* by Parrot & Clastrier (1946) since I have seen but few specimens of that form. The type was studied (Mus. Nat. Hist. Nat., Paris), which agrees with their description except the aedeagus is more rounded apically and not so angulate in sideview as illustrated by Parrot & Clastrier (1946, figs. 3–1).

In view of the few, but consistent, differences between *langeroni* and *orientalis* and their allopatric distribution (fig. 10), I agree with Theodor (1958) that *orientalis* is a subspecies of *langeroni*.

Phlebotomus (Phlebotomus) papatasi (Scopoli)
Fig. 11.

Bibio papatasi Scopoli, 1786, Deliciae faunae et flora insubricae, **1**: 55.

Phlebotomus papatasi: Theodor, 1938, Bull. Ent. Res. **29**: 165. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 41. Abonnenc, 1959b, Arch. Inst. Pasteur Alg. **37**: 329. Schmidt & Schmidt, 1962, Ann. Ent. Soc. Amer. **55**: 722; 1963, Ann. Ent. Soc. Amer. **56**: 567.

Phlebotomus (*Phlebotomus*) *papatasi*: Parrot, 1937, Arch. Inst. Pasteur Alg. **15**: 111. Ristorcelli, 1939, Arch. Inst. Pasteur Alg. **17**: 237. Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 627;

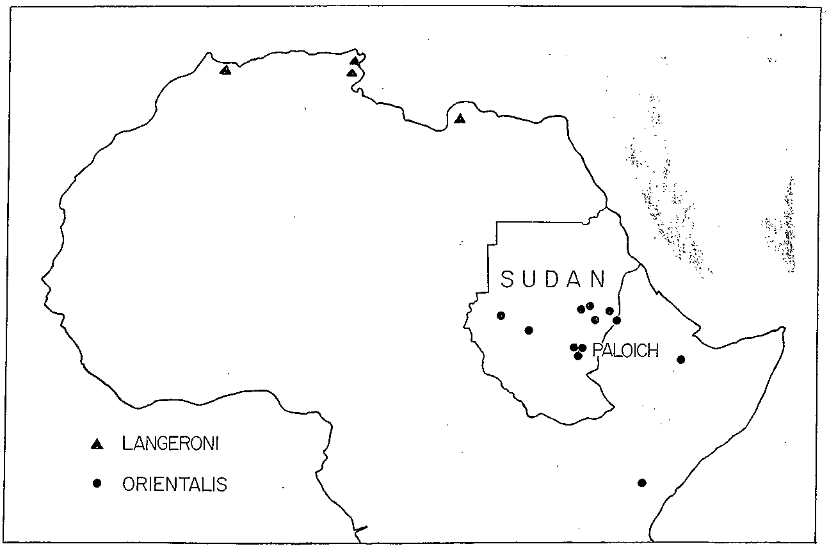

Fig. 10. Distribution of *Phlebotomus langeroni langeroni* and *P l. orientalis* in northern Africa.

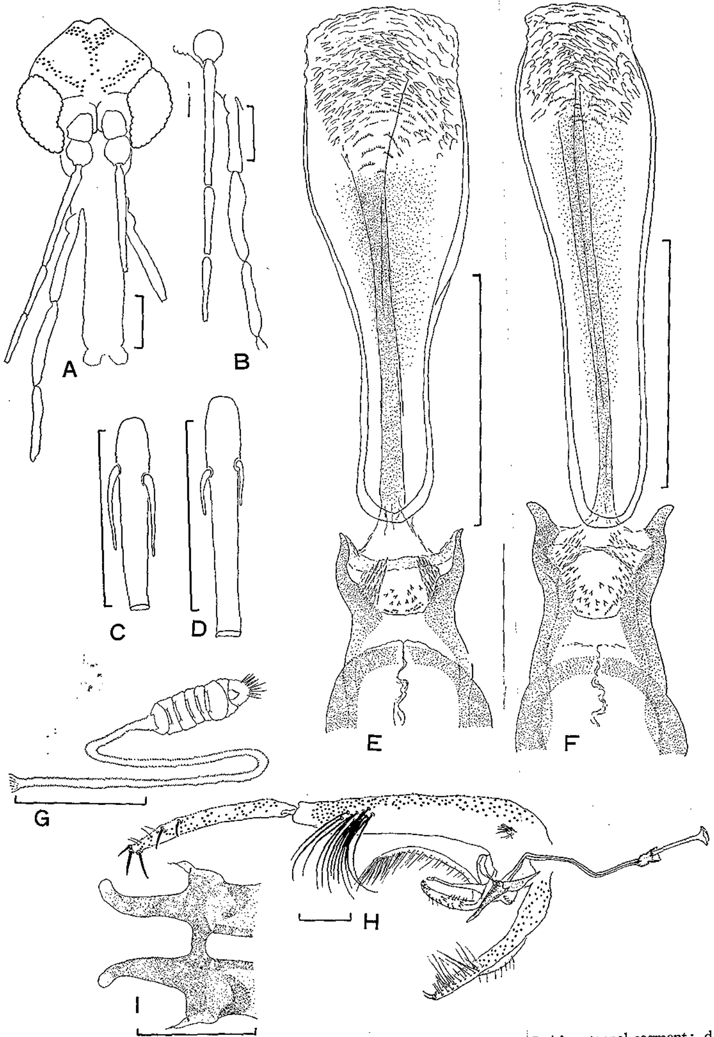

Fig. 11. *Phlebotomus papatasi*. a, ♀ head; b, ♂ antenna base and palp; c, ♀ 4th antennal segment; d, ♂ 4th antennal segment; e, ♀ cibarium and pharynx; f, ♂ cibarium and pharynx; g, ♀ spermatheca; h, ♂ genitalia, lateral view; i, ♂ aedeagus, dorsal view.

1946a, Ann. Trop. Med. Parasit. **40**: 41; 1951, Trans. R. Ent. Soc. London, **102**: 421; 1952, Ann. Trop. Med. Parasit. **46**: 339. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 632. Theodor, 1958, Flieg. Pal. Reg., Lief. **102**: 17. Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 594.

Large species, metanotum brownish, pleuron and coxae pale colored; pharynx of ♀ lightly pigmented, with scale-like folds distally.

♀. Cibarium (fig. 11e) with numerous spicules laterally and few, scattered setiform teeth anteriorly; pigment patch absent; chitinous arch well developed. Pharynx (fig. 11e) lightly pigmented centrally, maximum width 2.7×minimum, distally with scale-like folds ending in blunt tips, and few setose ridges. Epipharynx 1.2–1.6× length of antennal segment 3. Antenna (fig. 11a) with segment 3 subequal to 4+5 combined, may be little shorter or little longer, extending to center or distal 3/4 of palpal segment 2; ascoids (fig. 11c) paired on segments 3–15, 0.3–0.5 length of segment 4. Palpal formula usually 1–4–2–3–5, but sometimes 1–2–4–3–5, average ratio=30: 29: 22: 35; segment 3 with large patch of Newstead scales at basal 1/3. Wing with R_{2+3} 0.5–0.9× length of R_2, R_1 apex (delta) 0.2–0.4 length of R_2. Spermatheca (fig. 11g) with 8–12 well defined segments, apical knob withdrawn, fringing setae appear detached from knob, duct long, slender, not joined to other duct as base.

Measurements: Antenna 3=0.24±0.01 mm (0.21–0.27); 4+5 = 0.24 ± 0.02 mm (0.21–0.30). Epipharynx=0.32±0.02 mm (0.29–0.36). Wing length=2.03±0.01 mm (1.76–2.33); width=0.58±0.04 mm (0.45–0.66). 50 specimens.

♂. Cibarium (fig. 11f) similar to ♀ but smaller. Pharynx (fig. 11f) more slender than ♀ but with similar distal armature. Epipharynx 0.7–0.9× length of segment 3. Antenna (fig. 11b) with segments 3,4,5, longer than in ♀ but 3 extending beyond tip of palpal segment 2; ascoids (fig. 11d) paired on segments 3–15, short, 0.2–0.3 length of 4. Average palpal ratio=18: 18: 15: 34. Genitalia (fig. 11h): Dististyle with 5 short spines, 2 of which apical, 1 subapical and 2 at distal 1/4; basistyle with clump of about 12 large, nondeciduous hairs at distal 1/4 and setiferous tubercle near base; paramere trilobed, upper lobe longest; aedeagus (fig. 11i) elongate conical; surstyle with 2 short, apical spines; genital filaments about 2.5–3× pump length.

Measurements: Antenna 3=0.27±0.02 mm (0.23–0.30); 4+5=0.29±0.01 mm (0.27–0.31). Epipharynx=0.23±0.01 mm (0.20–0.24). Wing length=2.01±0.07 mm (1.85–2.12); width=0.50±0.03 mm (0.43—0.55). 50 specimens.

Distribution: Algeria, Tunisia, Chad, Egypt, Sudan, Ethiopia, Eritrea, Somalia; Mediterranean east to India.

Sudan: Northern, Darfur, Kordofan, Khartoum, Kassala, Blue Nile, Upper Nile Provinces.

P. papatasi is separable from most other species by the lightly pigmented pharynx with a light armature of folds instead of definite spines in the ♀♀ and the characteristic ♀ spermatheca and ♂ genitalia. The ♀♀ of *P. papatasi* are distinguished from *orientalis* by the longer antennal ascoids, less dense pharyngeal armature and spermathecae with withdrawn apical knobs; the ♂ genitalia of the two species are entirely dissimilar, notably in the shape and arrangement of the dististyle spines and structure of the aedeagus.

Females of *papatasi* are apparently indistinguishable from those of *duboscqi*, but the ♂♂ are distinct and at present these two species can only be separated with certainty when ♀♀ are associated with ♂♂. Males of *papatasi* differ from *duboscqi* by the shorter antennal ascoids and the upper lobe of the paramere extending far beyond the tips of the other two lobes.

Phlebotomus (Phlebotomus) duboscqi Neveu-Lemaire Fig. 12.

Phlebotomus duboscqi Neveu-Lemaire, 1906, Bull. Soc. Fran. **1909**: 164. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 40. Abonnenc, 1958, Arch. Inst. Pasteur Alg. **36**: 61. Abonnenc & Larviere, 1958, *Ibid.* **36**: 259. Abonnenc, 1959a, *Ibid.* **36**: 61; *Ibid.* **37**: 329.

Phlebotomus (*Phlebotomus*) *duboscqi*: Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 41; 1951, Trans. R. Ent. Soc. London, **102**: 427. Theodor, 1958, Flieg. Pal. Reg., Leif. 201, p. 18. Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 594.

Phlebotomus roubaudi Newstead, 1913, Bull. Soc. Path. Exot. **6**: 124. Parrot & Gougis, 1944, Arch. Inst. Pasteur Alg. **22**: 40. Rageau, 1951, Bull. Soc. Path. Exot. **44**: 794. (Types: Timbuctoo, Mali; BMNH.) Synonymy after Abonnenc, 1958.

Phlebotomus (*Phlebotomus*) *roubaudi*: Parrot, Mornet & Cadenat, 1945, Arch. Inst. Pasteur Alg. **23**: 241. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 42; 1948, *Ibid.* **42**: 325; 1951, Trans R. Ent. Soc. London, **102**: 424; Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 634.

Phlebotomus roubaudi var. *fourtoni* Floch & Abonnenc, 1948, Inst. Pasteur Guyane Territoire de l'Inini, Publ. 169. (Types: Mali (French Sudan); Pasteur Institute, Cayenne.) Synonymy after Abonnenc 1958.

Phlebotomus (*Phlebotomus*) *roubaudi* var. *fourtoni*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. London, **102**: 325.

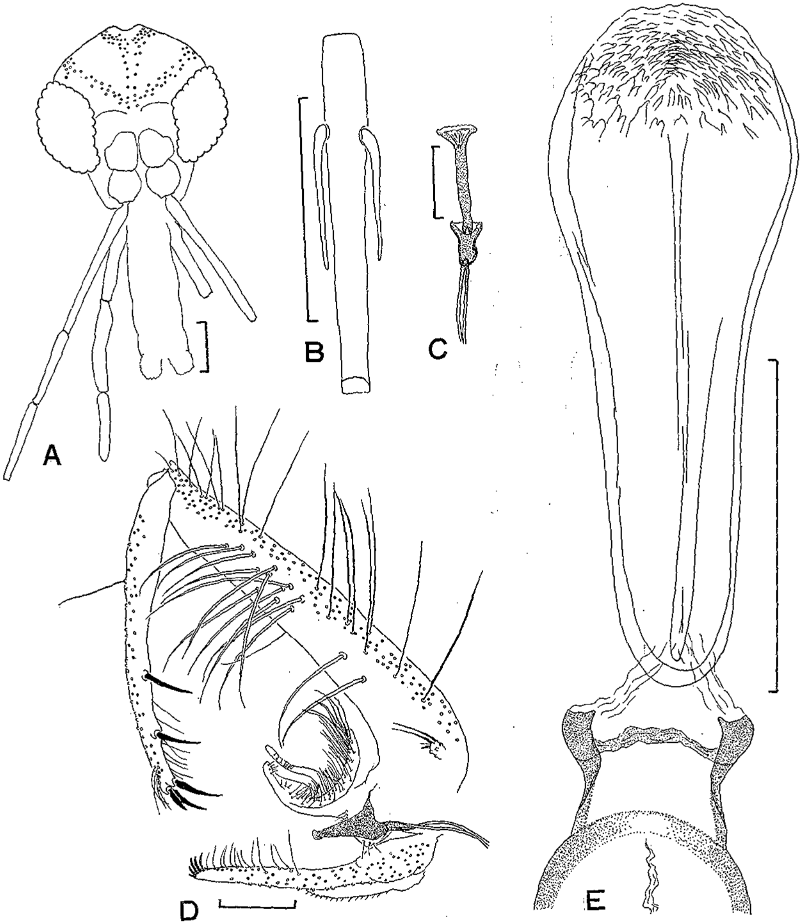

Fig. 12. *Phlebotomus duboscqi*, ♂. a, head; b, 4th antennal segment; c, genital pump; d, genitalia, lateral view; e, cibarium and pharynx (spicules in cibarium not evident, but probably present).

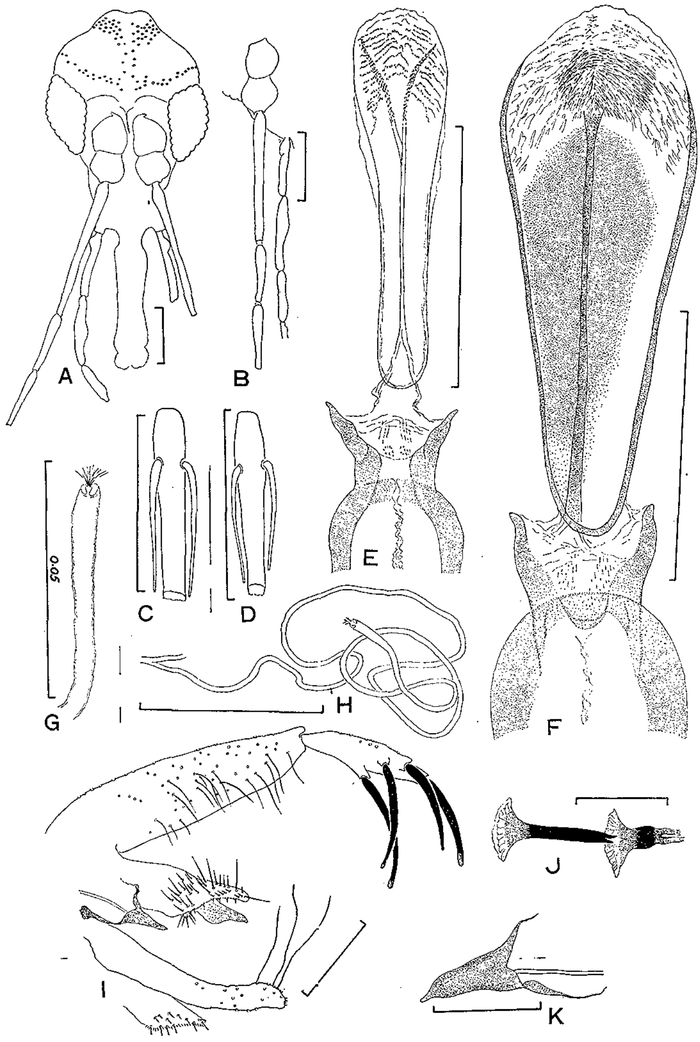

Fig. 13. *Phlebotomus rodhaini*. a, ♀ head; b, ♂ antennal base and palp; c, ♀ 4th antennal segment; d, ♂ 4th antennal segment; e, ♂ cibarium and pharynx; f, ♀ cibarium and pharynx; g, ♀ spermatheca; h, ♀ spermatheca and duct; i, ♂ genitalia, lateral view; j, ♂ genital pump; k, ♂ aedeagus, lateral view.

♀. Indistinguishable from *papatasi* (no specimens seen; see Abonnenc 1959).

♂. Pharynx (fig. 12e) maximum width 1.5–2.0 minimum, apex with scale-like denticles. Antenna with segments 3 and 4+5 combined subequal in length, 3 extending to basal 1/3 of palpal segment 3 (fig. 12a); ascoids (fig. 12b) paired on segments 3–15 about 0.4 length of 4. Palpal formula 1–2–4–3–5, ratio=18:18 (or 19):15:40; segment 3 with small patch of Newstead scales at basal 1/3. Wing (fig. 5c) with R_{2+3} 0.6–0.7 length of R_2, R_1 apex (delta) 0.2–0.3 length of R_2. Tergites 5 & 6 subequal in size. Genitalia (fig. 12d): Dististyle with 5 spines, 2 apical, 1 subapical, 1 at distal 1/6 and 1 at distal 1/3; basistyle with cluster of 11–13 nondeciduous hairs beyond center and 2 before center; aedeagus variable in shape depending on position, either tapering over whole length to small, blunt apex or stout and abruptly reduced to small, nipple-like apex; paramere trilobed, upper lobe slender, curved, thickly covered with hair and not extending beyond other lobes; surstyle slender, armed with 5 small, apical spines.

Measurements: Antenna 3=0.28–0.33 mm; 4+5=0.30–0.33 mm. Epipharynx=0.26 mm. Wing length =2.12–2.33 mm; width=0.52–0.60 mm.

Types: Timbuctoo, Mali; location unknown.

Distribution: Mauritania, Mali, Sierra Leone, Ghana, Togo, Upper Volta, Niger, Nigeria, Cameroon, Sudan, Saudi Arabia.

Sudan: Kordofan, Blue Nile, Upper Nile, Equatoria Provinces.

Phlebotomus (Phlebotomus) rodhaini Parrot
Fig. 13.

Phlebotomus rodhaini Parrot, 1930, Rev. Zool. Bot. Afr. **19**: 187.

Phlebotomus (*Phlebotomus*) *rodhaini*: Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 42; 1951, Trans. R. Ent. Soc. London, **102**: 437; 1952, Ann. Trop. Med. Parasit. **46**: 341.

Phlebotomus (*Anaphlebotomus*) *rodhaini*: Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 594.

Large species, metanotum brownish, pleuron and coxae pale, except apices and posterior borders of coxae slightly darkened; pharynx of ♀ pigmented centrally and distally armed with cluster of spines.

♀. Cibarium (fig. 13f) with numerous spicules laterally and few, scattered setiform teeth anteriorly; pigment patch absent; chitinous arch well developed, crescent-shaped structure below center of arch. Pharynx (fig. 13f) pigmented centrally, maximum width about twice minimum, distally with numerous spines in close-set rows, spinose area darkened, few setose ridges above spines. Epipharynx shorter than antennal segment 3. Antenna (fig. 13a) with segment 3 longer than 4+5 combined, extending beyond tip of palpal segment 2 to basal 1/4 of segment 3; ascoids (fig. 13c) paired on segments 3–15 usually 0.7 length of segment 4. Palpus short, formula 1–4–2–3–5, average ratio=14:15:8:16; segment 3 with patch of Newstead scales at basal 1/3. Wing with R_{2+3} 0.5–0.8×length of R_2, R_1 apex 0.1–0.2 length of R_2. Spermatheca (figs. 13g, h) cylindrical, slender, little wider than duct, apical knob withdrawn, duct very long, coiled several times within body.

Measurements: Antenna 3=0.26±0.02 mm (0.24–0.28); 4+5=0.22±0.01 mm (0.21–0.24). Epipharynx=0.21±0.02 mm (0.18–0.22). Wing length=1.91±0.07 mm (1.80–2.06); width=0.51±0.02 mm (0.48–0.58). 25 specimens.

♂ Cibarium (fig. 13e) similar to ♀ but smaller and without crescent below arch. Pharynx (fig. 13e) smaller than ♀, only lightly pigmented, distally with many setose folds. Antenna (fig. 13b) with segments 3,4,5 shorter than in ♀, 3 extending to center of palpal segment 3; ascoids (fig. 13d) paired on segments 3–13, 0.6–0.8 length of 4. Average palpal ratio=10:12:7:15. R_1 apex usually ending at level of R_{2+3} fork. Genitalia (fig. 13i-k): Dististyle with 4 long spines, 1 of which apical, 1 at distal 1/4 and 2 near center; basistyle with few nondeciduous hairs, without setiferous tubercle; aedeagus short, triangular; genital filaments long, 3–4×pump length.

Measurements: Antenna 3=0.22±0.02 mm (0.20–0.25); 4+5=0.20±0.01 mm (0.18–0.22). Epipharynx=0.14±0.01 mm (0.12–0.15). Wing length=1.62±0.07 mm (1.52–1.74); width=0.42±0.03 mm (0.34–0.47). 27 specimens.

Types: Mandinba, Congo Rep.; Mus. Roy. Afr. Centr., Tervueren.

Distribution: Congo, Sudan, Uganda.

Sudan: Kassala, Upper Nile, Equatoria Provinces.

The pigmented pharynx and long, coiled spermathecal ducts distinguish *rodhaini* from other ♀♀. The ♂ is the only one of the subgenus *Phlebotomus* in the area which has but 4 spines on the dististyle; the bilobed paramere and large genital pump are also distinctive.

Phlebotomus (Phlebotomus) heischi Kirk & Lewis
Fig. 14.

Phlebotomus (*Phlebotomus*) *heischi* Kirk & Lewis, 1950, Proc. R. Ent. Soc. London (B), **19**: 11; 1951, Trans. R. Ent. Soc. Lond. **102**: 436.

Phlebotomus heischi: Qutubuddin, 1961, Ann. Mag. Nat. Hist. ser. 13, **3**: 605 (♂ descr.).

Phlebotomus (*Euphlebotomus*) *heischi*: Qutubuddin, 1962, *Ibid.* **4**: 594.

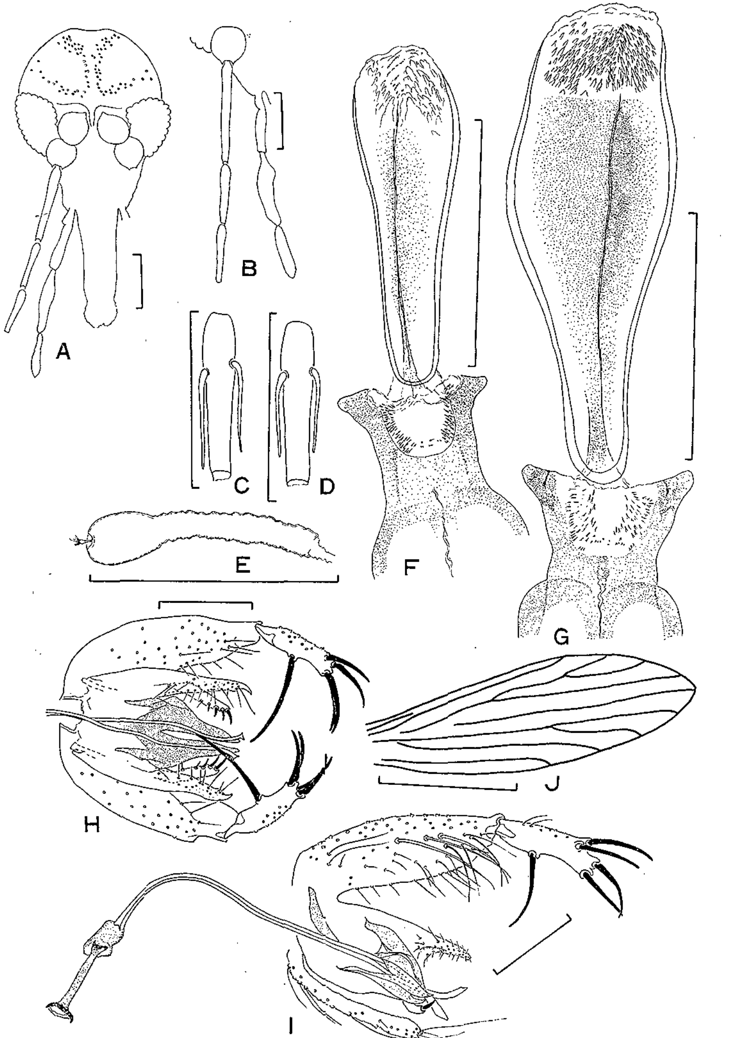

Fig. 14. *Phlebotomus heischi.* a, ♀ head; b, ♂ antennal base and palp; c, ♀ 4th antennal segment; d, ♂ 4th antennal segment; e, ♀ spermatheca; f, ♂ cibarium and pharynx; g, ♀ cibarium and pharynx; h, ♂ genitalia, dorsal view; i, ♂ genitalia, lateral view; j, ♀ wing.

Medium-sized species, metanotum brownish, pleuron and coxae pale colored; pharynx of ♀ strongly pigmented centrally and armed distally with dense cluster of spines.

♀. Eyes smaller than other species. Cibarium (fig. 14g) with numerous spicules laterally and few, scattered setiform teeth anteriorly; pigment patch rectangular; chitinous arch well developed, extending anteriorly as broad, median extension. Pharynx (fig. 14g) strongly pigmented centrally, maximum width 2–2.5× minimum, distally with large, dense cluster of spines. Clypeus enlarged and protuberant when viewed laterally; epipharynx 1.1–1.6× length of antennal segment 3. Antenna (fig. 14a) with segment 3 shorter than 4+5 combined, rarely equal in length, extending to distal 3/4 or tip of palpal segment 2; ascoids (fig. 14c) paired on segments 3–14, absent from 15, 16, 0.5–0.6 length of segment 4. Palpal formula 1–4–2–3–5, average ratio=16: 17: 11: 21; segment 3 with large patch of Newstead scales at basal 1/3. Wing (fig. 14j) with R_{2+3}, 1.4–2.0×length of R_2, R_1 apex (delta) 0–0.4 length of R_2. Spermatheca (fig. 14e) long and sac-like, apical 1/3 slightly bulbous, apical knob protuberant, small with clavate, sparsely haired tip; duct very short and wrinkled; reticulated sac-like structure near spermatheca.

Measurements: Antenna 3=0.17±0.01 mm (0.15–0.20); 4+5=0.20±0.02 mm (0.17–0.23). Epipharynx =0.24±0.02 mm (0.20–0.28). Wing length=1.78±0.15 mm (1.51–2.11); width=0.43±0.05 mm (0.35–0.58). 50 specimens.

♂ Cibarium (fig. 14f) similar to ♀ but smaller; pigment patch triangular or rectangular; chitinous arch less strongly developed and with faint median extension. Pharynx (fig. 14f) slender, less heavily pigmented than ♀ and with multiple, blunt folds distally. Epipharynx shorter than antennal segment 3, 0.6–0.9 length of segment 3. Antenna (fig. 14b) with segments 3,4,5 about same length as ♀, but 3 extending beyond tip of palpal segment 2; ascoids (fig. 14d) paired on segments 3–14, absent from 15, 16, 0.4–0.5 length of 4. Genitalia (fig. 14h,i): Dististyle with 5 spines, 2 of which apical, 2 at about distal 4/5 and larger one at center; basistyle with few, large, nondeciduous hairs; paramere bilobed, lower lobe with 4 or 5 thick spines; genital filaments about 3× pump length.

Measurements: Antenna 3=0.17±0.01 mm (0.14–0.19); 4+5=0.20±0.01 mm (0.17–0.22). Epipharynx=0.13±0.01 mm (0.10–0.15). Wing length=1.60±0.1 mm (1.36–1.84); width=0.38±0.04 mm (0.31–0.47). 50 specimens.

Holotype: ♀, Kenya; BMNH.

Distributions: Sudan, Kenya.

Sudan: Kassala, Upper Nile Provinces.

♀♀ of *heischi* are readily distiguished by the broad, pigmented pharynx from other species in the area, except *rodhaini* and *lesleyae*. From *rodhaini*, *heischi* is distinguished by the shorter antennal segment 3, differences of the cibarium as illustrated, and the sac-like spermatheca as compared to the very long, slender spermatheca and duct of *rodhaini*.

The long ascoids of *heischi* is apparently the only feature distinguishing the ♀ from that of *lesleyae*, which has very short ascoids. The ♂ genitalia of *heischi* is unique and readily recognized by the bilobed paramere with the large spines on the lower lobe.

Phlebotomus (Phlebotomus) lesleyae Lewis & Kirk Fig. 15.

Phlebotomus (*Phlebotomus*) *lesleyae* Lewis & Kirk, 1946, Proc. R. Ent. Soc. London, (B) **15**: 55. Kirk & Lewis, 1948, Ann. Trop. Med. Parasit. **42**: 322; 1951, Trans. R. Ent. Soc. London. **102**: 435; 1952, Ann. Trop. Med. Parasit. **46**: 341. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist. ser. 12, **10**: 634.

Phlebotomus (*Euphlebotomus*) *lesleyae*: Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 594.

Medium-sized species, pharynx of ♀ pigmented centrally and distally armed with dense cluster of spines.

♀ (partly after Kirk & Lewis, 1951). Eyes (fig. 15a) smaller than in other species. Cibarium (fig. 15d) with numerous spicules laterally and anteriorly, probably with few, scattered setiform teeth in anterior part, but not visible in specimen examined; pigment patch shield-shaped; chitinous arch well developed, extending medially as broad, anterior extension. Pharynx (fig. 15d) pigmented centrally, maximum width 2.5×minimum, distally with large, dense cluster of spines. Clypeus enlarged and moderately protuberant when viewed laterally; epipharynx slightly shorter than antennal segment 3. Antenna with segment 3 shorter than 4+5 combined, extending to distal 3/4 or palpal segment 2 (fig. 15a); ascoids paired, clavate, very short, about 1/3 length of segment 4 (fig. 15b). Palpal formula 1–4–(2–3)–5, segment 3 with large patch of Newstead scales at proximal 1/3. Wing with R_{2+3} 3×R_2, R_1 (delta) not reaching R_{2+3} fork. Spermatheca (fig. 15c) long and sac-like, apical 1/3 slightly bulbous, apical knob protuberant, small with clavate, sparsely haired tip; duct very short, and wrinkled; reticulated sac-like structure near spermatheca.

Measurements: Antenna 3=0.16 mm; 4+5=0.19 mm; epipharynx=0.17 mm. Wing length=1.48 mm; width=0.29 mm. 1 specimen.

♂ (after Kirk & Lewis, 1951). Pharynx slender, maximum width scarcely exceeding minimum. Epipharynx about 3/4 length of antennal segment 3.

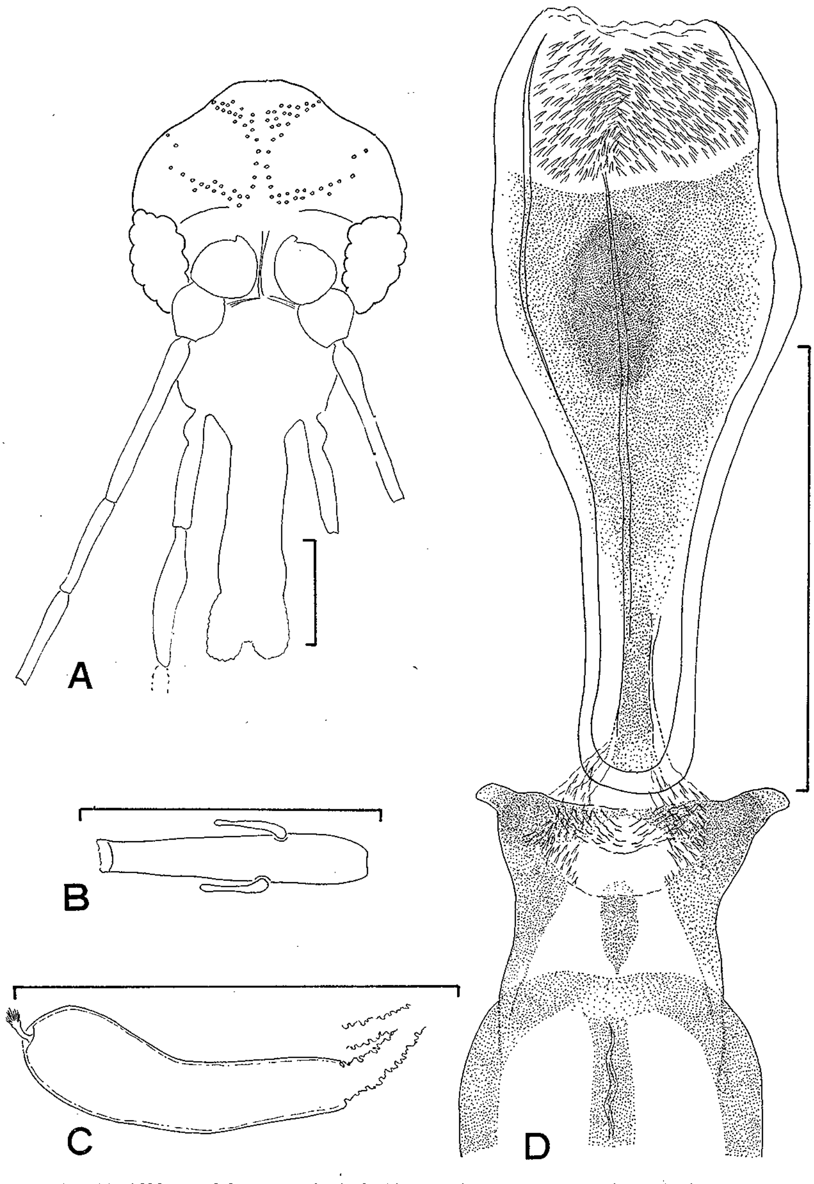

Fig. 15. *Phlebotomus lesleyae*, ♀. a, head; b, 4th antennal segment; c, spermatheca; d, cibarium and pharynx.

Ascoids paired, 1/5 length of segment 4. Genitalia: Dististyle with 5 spines, 2 of which apical, 3 distributed between center and distal 3/4, proximal spine much longer than others; aedeagus conical with blunt tip; paramere trilobed, upper and lateral lobes digitiform, upper longer, central lobe broad and flattened.

Measurements: Antenna 3 = 0.12 mm. Wing length=1.14 mm; width=0.18 mm. No specimens examined.

Types: 1 ♀, 1 ♂, Nuba Mts., Kordofan Prov., Sudan; BMNH.

Distribution: Sudan.

Sudan: Kordofan, Kassala, Blue Nile, Upper Nile Provinces.

♀♀ of *lesleyae* and *heischi* appear indistinguishable except the antennal ascoids are very short in *lesleyae* and in *heischi* they are long and extend nearly to the apices of the antennal segments. ♂♂ are separable on characters of the genitalia and it is unlikely the two would be confused. (See Kirk & Lewis, 1951, for illustration of *lesleyae* ♂ genitalia.)

Subgenus **Sergentomyia** França & Parrot

Phlebotomus (*Newsteadia*) França, 1919, Broteria, **17**: 148. Preoccupied by Green, 1902, Hemiptera.

Phlebotomus (*Sergentomyia*) França & Parrot, 1920, Bull. Soc. Path. Exot. **13**: 696. França, 1921, Bull. Soc. Portug. Sci. Nat. **8**: 215. França & Parrot, 1921, Arch. Inst. Pasteur Afriq. Nord. **1**: 279. Larrousse, 1921, Étude Syst. et Med. des Phlébotomes, p. 18. Kirk & Lewis, 1951, Trans. R. Ent. Soc. London, **102**: 413.

Sergentomyia: Theodor, 1948, Bull. Ent. Res. **39**: 100; 1958, Flieg. Pal. Reg. Lief. 201, p. 33.

Phlebotomus (*Neophlebotomus*) França & Parrot, 1920, Bull. Soc. Path. Exot. **13**: 699. Larrousse, 1921, Étude Syst. et Med. des Phlébotomes, p. 18. Dyar, 1929, Amer. Jour. Hyg. **10**: 118. Type species: *Phlebotomus malabaricus* Annandale, by monotypy (and subseq. desig. by Larrousse, 1921.)

Phlebotomus (*Prophlebotomus*) França & Parrot, 1921, Arch. Inst. Pasteur Afriq. Nord, **1**: 280. Dyar, 1929, Amer. Jour. Hyg. **10**: 119. Parrot, 1934, Arch. Inst. Pasteur Alg. **12**: 391. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 37. Parrot, 1951, Arch. Inst. Pasteur Alg. **29**: 40. Type species: *Phlebotomus minutus* Rondani, by subseq. desig. Dyar, 1929.

Phlebotomus (*Sintonius*) Nitzulescu, 1931, Ann. Paras. Hum. Comp. **9**: 271. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 37; Theodor, 1948, Bull. Ent. Res. **39**: 103. Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 413. Type species: *Phlebotomus hospitii* Sinton, by orig. desig. **New synonymy.**

Sergentomyia (*Sintonius*) Theodor, 1948, Bull. Ent. Res. **39**: 103; 1958, Flieg. Pal. Reg., Lief. 201, p. 51.

Sergentomyia (*Parrotomyia*) Theodor, 1958, Flieg. Pal. Reg. Lief. 201, p. 42. Type species: *Phlebotomus africanus* Newstead, by orig. desig. **New synonymy.**

Sergentomyia (*Grassomyia*) Theodor, 1958, Flieg. Pal. Reg., Lief. 201, p. 47. Type species: *Phlebotomus squamipleuris* Newstead, by orig. desig. **New synonymy.**

Type species: *Phlebotomus minutus* Rondani, by subseq. desig. França, 1921.

Cibarium with well developed armature in form of row of horizontal teeth, most strongly developed in ♀; pigment patch usually conspicuous. Palpal formula variable, segment 4 longer or little shorter than 3.

R_{2+3} longer or shorter than R_2. Abdomen largely with recumbent hairs (small sockets) on tergites 2–6, when erect hairs (large sockets) present, confined to posterior margin of tergites. ♂ genitalia: Dististyle with 4 spines, all often terminal, and accessory seta; paramere a simple, digitate structure. Species generally smaller and darker colored than in *Phlebotomus*.

I cannot accept the elevation of *Sergentomyia* to the rank of genus as proposed by Theodor (1948, 1958). In my opinion, there are neither morphological nor biological features strong enough to support generic rank for the group. Furthermore, it is a disservice to other workers to split a medically important group without a great deal more evidence than present within the genus *Phlebotomus*.

At the same time, I do not feel that *Sintonius* is a valid subgenus nor can I admit *Parrotomyia* and *Grassomyia* in my classification. The characters of the species included in those groups do not justify subgeneric rank, in my opinion, nor is the Old World *Phlebotomus* such a complex genus that it needs extensive subdivision at present.

P. minutus was clearly selected as the type species of *Sergentomyia* by França (1921) and the group must be based on that species. Yet, it is argued by Parrot (1951) that the type species of *Sergentomyia* is *P. perniciosus* Newstead (1911) because the inclusion of an unnamed figure of the ♂ genitalia of this species with the description of the genus (França & Parrot 1920) constituted the designation of a type species. If this were true, *Sergentomyia* would become a synonym of *Phlebotomus* in this paper or replace *Larroussius* Nitzulescu (Theodor 1948). However, merely including a figure is not a valid type designation [Int. Code Zool. Nomen. Art. 67 (c)] and *perniciosus* cannot be considered the type species of *Sergentomyia*. Furthermore, Parrot & França (1921: 279) clearly and

unambiguously designate *minutus* as the type species of *Sergentomyia*, which action would also take precedence over the inclusion of the genitalia illustration.

Phlebotomus (Sergentomyia) clydei Sinton Figs. 16a-g.

Phlebotomus clydei Sinton, 1928, Ind. Jour. Med. Res. **16**: 179. Lewis & Kirk, 1939, Proc. R. Ent. Soc. Lond. ser. B, **8**: 155. Kirk & Lewis, 1948, Ann. Trop. Med. Parasit. **42**: 326. Rageau, 1951, Bull. Soc. Path. Exot. **44**: 795.

Phlebotomus (*Prophlebotomus*) *clydei*: Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 630. Parrot & Martin, 1944, Arch. Inst. Pasteur Alg. **22**: 55. Parrot, Mornet and Candenat, 1945, *Ibid.* **23**: 232, 240. Parrot, 1946, *Ibid.* **24**: 71. Parrot & Durand-Delacre, 1947, *Ibid.* Parrot, 1948, *Ibid.* **26**: 274. Parrot & Clastrier, 1960, *Ibid.* **38**: 73. Abonnenc & Rioux, 1961, Mission épidem. Nord-Tchad, p. 35.

Phlebotomus (*Sintonius*) *clydei*: Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 42; 1948, *Ibid.* **42**: 325; 1951, Trans. R. Ent. Soc. Lond. **102**: 445; 1952, Ann. Trop. Med. Parasit. **46**: 341. Heisch, Guggisberg, & Teesdale, 1956, Trans. R. Soc. Trop. Med. Hyg. **50**: 212. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 638.

Sergentomyia (*Sintonius*) *clydei*: Theodor, 1958, Fleig. Pal. Reg., Lief. 201, p. 51.

Phlebotomus (*Prophlebotomus*) *vagus* Parrot & Martin, 1939, Arch. Inst. Pasteur Alg. **17**: 147. (Types: Ethiopia; IPA). Synonymy after Parrot & Martin, 1944.

Phlebotomus (*Prophlebotomus*) *viator* Parrot & Martin, 1939, Arch. Inst. Pasteur Alg. **17**: 153 (Types: Ethiopia; IPA). Kirk & Lewis, 1946a, Proc. R. Ent. Soc. London, ser. B, **15**: 50. Synonymy after Parrot & Durand-Delacre, 1947.

Medium-sized species with sharp, spike-like teeth and pharynx without large spines.

♀. Cibarium (fig. 16g) with row of 10–16 large, sharply pointed, spike-like teeth in even row, lateral and sometimes central teeth smaller than others, 16–34 erect teeth usually in single row but sometimes in double row (as illustrated); pigment patch triangular with tapering anterior projection, sometimes with small, hemispherical posterior knob behind teeth (as illustrated); chitinous arch well developed. Pharynx (fig. 16c) gradually or abruptly expanded posteriorly with several irregular rows of setae, maximum width 1.5–2× minimum. Epipharynx 1.3–1.6 length of antenna segment 3. Antenna with segment 3 shorter than 4+5 combined, extending to about middle of palpal segment 2 (fig. 16a) ascoids paired on segments 3–15, 0.4–0.5 length of segment 4. Palpal formula 1–2–4–3–5, ratio=11: 13.5: 12: 28; segment 3 with large patch of Newstead scales near base and enlarged basally. Wing with R_{2+3} usually 1.2× (1.0–2.0×) R_2, R_1 apex (delta) usually 0.3 length of R_2. Tergites 2–6 with few erect hairs (large sockets) on mediodistal margin. Spermatheca (fig. 16d) distinctly segmented, with 6–9 segments, duct very long and slender; apical knob protuberant.

Measurements: Antenna 3=0.14±0.01 mm (0.12–0.16); 4+5=0.16±0.01 mm (0.14–0.18). Epipharynx =0.20±0.01 mm (0.17–0.23). Wing length=1.80±0.1 mm (1.57–2.06); width=0.44±0.04 mm (0.36–0.55). 50 specimens.

♂. Cibarium (fig. 16f) armed with 16–26 small, spike-like teeth irregularly distributed, usually in clusters of 2 or 3, 7–18 erect teeth usually in single row, but sometimes with partial or complete second row (as illustrated); pigment patch top-shaped or triangular with anterior projection; chitinous arch darker than in ♀. Pharynx more slender than ♀, with apical setae. Epipharynx 1.1–1.4× antenna segment 3. Antenna segments 3,4,5 little longer than in ♀♀; ascoids single on segments 3–15, 0.3–0.5 length of segment 4. Tergites 2–6 usually without erect hairs. Tergites 6 1.3–1.7× 5 length and width (in Paloich specimens). Genitalia (fig. 16e): Dististyle with 2 apical and 2 subapical spines, seta at distal 4/5; basistyle with few nondeciduous hairs on inner face; aedeagus small, sharply pointed at apex; genital filament 5–6× pump length; paramere with beak-like apex.

Measurements: Antenna 3=0.15±0.01 mm (0.13–0.17); 4+5=0.17±0.01 mm (0.16–0.19). Epipharynx=0.18±0.01 mm (0.16–0.21). Wing length=1.73±0.1 mm (1.55–1.92); width=0.41±0.03 mm (0.36–0.47). 50 specimens.

Types: 11 ♀♀, 10 ♂♂, Waziristan, India; BMNH.

Distribution: Algeria, Mali, Senegal, Ghana, Niger, Chad, Cameroon, Sudan, Eritrea, Ethiopia, Fr. Somaliland, Kenya, Iraq, So. USSR (Turkestan), India.

Sudan: Northern, Darfur, Kordofan, Kassala, Blue Nile, Upper Nile Provinces.

♀♀ of *clydei* are separable from other *Phlebotomus* species in the area, except *adleri*, by the distinct cibarial teeth and pigment patch and annulated spermatheca. The ♂ cibarium is also distinctive, but not as easily seen as in the ♀. The ♂ genitalia is similar only to *africanus*, but in that species the aedeagus is larger and the basistyle has more nondeciduous hairs. In the Paloich area, all ♂♂ of *clydei* have an enlarged tergite 6, which quickly separates them from *africanus*. *P. clydei* is closely related to *adleri* and further discussion is given with that species.

Theodor (1958) has separated *clydei* into 2 subspecies. The nominate form with tergites 5 & 6 equal sized is stated to occur from Iraq to India; the subspecies *latiterga* with an enlarged tergite 6 in Africa. However, the 2 forms were found together in Chad by Abonnenc & Rioux (1961) and in Nigeria by Lewis & McMillan (1961). Only the form with the enlarged tergite 6 was found in Paloich.

Phlebotomus (Sergentomyia) adleri Theodor Figs. 16h-i.

Phlebotomus adleri Theodor, 1933, Bull. Ent. Res. **24**: 537; 1938, *Ibid.* **29**: 172. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 38. Rageau, 1951, Bull. Soc. Path. Exot. **44**: 795. Abonnenc, 1962, Arch. Inst. Pasteur Alg. **40**: 220.

Phlebotomus (*Prophlebotomus*) *adleri*: Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 630. Parrot & Bellon, 1952, Arch. Inst. Pasteur Alg. **30**: 60. Abonnenc & Rioux, 1961, Mission épidem. Nord-Tchad, p. 42.

Phlebotomus (*Sintonius*) *adleri*: Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 42; 1951, Trans. R. Ent. Soc. Lond. **102**: 439. Kirk & Lewis, 1952, Ann. Trop. Med. Parasit. **46**: 341. Heisch, Guggisberg and Teesdale, 1956, Trans. R. Soc. Trop. Med. Hyg. **50**: 212. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 638.

Sergentomyia (*Sintonius*) *adleri*: Qutubuddin 1962, Ann. Mag. Nat. Hist., ser. 13, **3**: 594.

♀. Same as *clydei*, except cibarium with 3–5 rows of 45 to 80 erect teeth (fig. 16h) and perhaps larger size and R_2 only 0.3–0.7 length of R_{2+3}.

Measurements: Antenna 3=0.15–0.16 mm; 4+5 =0.17–0.20 mm. Epipharynx=0.21–0.23 mm. Wing length = 1.68–2.00 mm; width = 0.39–0.47 mm. 10 specimens.

♂. Same as *clydei*, except cibarium with 2–3 rows of 16–24 erect teeth and tergite 6 subequal to 5 or little larger in size.

Measurements: Antenna 3=0.15–0.16 mm; 4+5 =0.17–0.20 mm. Epipharynx=0.21–0.23 mm. Wing length = 1.79– 2.00 mm; width = 0.39–0.42 mm. 15 specimens.

Types: 6 ♀♀, 11 ♂♂, Ghana (Gold Coast); cotype ♂ & ♀, BMNH.

Distribution: Ghana, Upper Volta, Nigeria, Chad, Cameroon, Sudan, Eritrea, Kenya.

Sudan: All provinces except Equatoria and Bahr el Ghazal.

♀♀ of *adleri* and *clydei* apparently differ only in the number and rows of erect teeth of the cibarium. However, there are variations in this character; some *adleri* ♀♀ have only 3 rows and some *clydei* have clearly two with an incipient third on the margins. ♂♂ of *adleri* and the nominate form of *clydei* with an unexpanded tergite 6 are separable only by the number of erect teeth, but this is less reliable than in the ♀♀. Some *P. adleri* ♂♂ only have 2 rows and in some *clydei* there is an incipient second row, so the division between these forms is not distinct. The form of *clydei* with the tergite 6 expanded, *c. latiterga*, differs conspicuously from *adleri* on the basis of this character.

I suspect that eventually *clydei* and *adleri* will be shown to be forms of the same species. The two do not differ greatly and often are taken together. In the Paloich populations there is seen a tendency toward intergradation of characters which are supposed to differentiate the two. It is quite possible that detailed studies of long series will show complete intergradation.

Phlebotomus (Sergentomyia) schwetzi Adler, Theodor & Parrot Fig. 17.

Phlebotomus schwetzi Adler, Theodor & Parrot, 1929, Rev. Zool. Bot. Afr. **18**: 75. Parrot, 1930, *Ibid.* **19**: 182. Theodor, 1938, Bull. Ent. Res. **29**: 172. DeMeillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 42. Parrot & Joliniere, 1945, Arch. Inst. Pasteur Alg. **23**: 56. Rageau, 1951, Bull. Soc. Path. Exot, **44**: 794. DeMeillon & Hardy, 1953, Jour. Ent. Soc. S. Afr. **16**: 32. Abonnenc, 1959, Arch. Inst. Pasteur Alg. **37**: 591.

Phlebotomus (*Prophlebotomus*) *schwetzi*: Parrot, 1937, Arch. Inst. Pasteur Alg. **15**: 118. Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 629. Parrot & Malbrant, 1945, Arch. Inst. Pasteur Alg. **23**: 121. Parrot, Mornet & Cadenat, 1945, *Ibid.* **23**: 240; 1945, *Ibid.* **23**: 281. Parrot & Martin, 1945, *Ibid.* **23**: 279. Kirk & Lewis, 1946, Ann. Trop. Med. Parasit. **40**: 49; 1948, *Ibid.* Parrot, 1948, Arch. Inst. Pasteur Alg. **26**: 268. Rageau & Adam, 1953, Bull. Soc. Path. Exot. **46**: 587. Abonnenc & Rioux, 1961, Mission épidem. Nord-Tchad. p. 44.

Phlebotomus (*Sergentomyia*) *schwetzi*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. London, **102**: 470; 1952, Ann. Trop. Med. Parasit. **46**: 345. Heisch, Guggisberg & Teesdale, 1956, Trans. R. Soc. Trop. Med. Hyg. **50**: 214. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 636.

Sergentomyia (*Sergentomyia*) *schwetzi*: Theodor, 1948, Bull. Ent. Res. **39**: 110; 1958, Flieg. Pal. Reg., Lief. 201, p. 40, Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 595.

Phlebotomus symesi Sinton, 1930, Ind. Jour. Med. Res. **18**: 175. (Types: Mombasa, Kenya; BMNH). Synonymy after Kirk & Lewis, 1946a.

Phlebotomus (*Prophlebotomus*) *schwetzi* var. *aethiopicus* Parrot, 1936a, Arch. Inst. Pasteur Alg. **14**: 39.

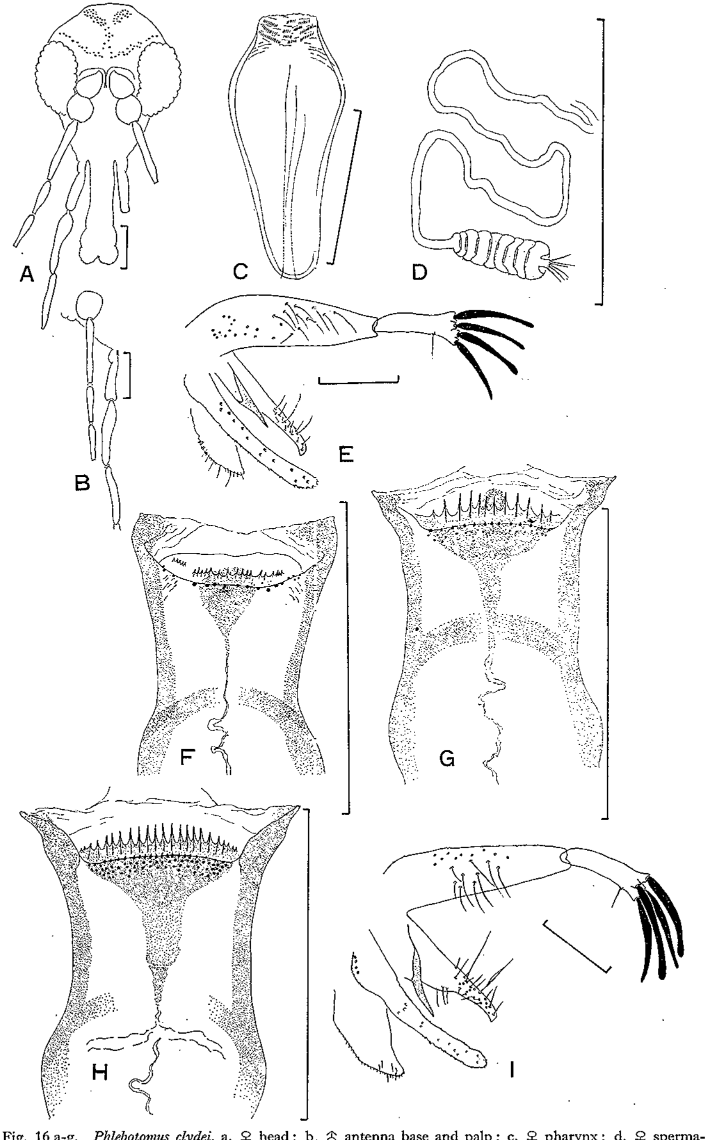

Fig. 16 a-g. *Phlebotomus clydei.* a, ♀ head; b, ♂ antenna base and palp; c, ♀ pharynx; d, ♀ spermatheca; e, ♂ genitalia, lateral view; f, ♂ cibarium; g, ♀ cibarium.
h-i. *Phlebotomus adleri*, h, ♀ cibarium; i, ♂ genitalia, lateral view.

(Types: Ethiopia; IPA). Parrot, 1937, Arch. Inst. Pasteur Alg. **15**: 118. Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 629; 1946a, Ann. Trop. Med. Parasit. **40**: 49. Synonymy after Parrot, Mornet & Cadenat, 1945.

Phlebotomus schwetzi var. *aethiopicus*: Parrot, 1938, Arch. Inst. Pasteur Alg. **16**: 213. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 42.

Phlebotomus (*Prophlebotomus*) *horgani* Kirk & Lewis, 1948, Ann. Trop. Med. Parasit. **4**: 323; 1951, Trans. R. Ent. Soc. Lond **102**: 492. (Types: Sudan; BMNH). ♀ only, synonymy after Lewis & Kirk, 1957.

Medium-sized species, metanotum and abdomen darker than thoracic pleuron; cibarium with dense, broad teeth bearing sharp points, those of ♀ reduced in center; pharynx with nearly straight, divergent sides, apex without spines.

♀. Cibarium (fig. 17a) with 14–21 broad teeth which abruptly taper to sharp, spine-like apices, about 6 in center much narrower than lateral ones, teeth sloping ventrally and centrally, no erect teeth observed, but several points on faint ridge below teeth probably are vestigial erect teeth; ventral wall pigmented from line below teeth to chitinous arch; pigment patch roughly elliptical with short, truncate anterior projection, but often obscured by pigmentation in ventral wall; chitinous arch well developed. Pharynx (fig. 17c) with sides divergent and nearly straight to distal 3/4,

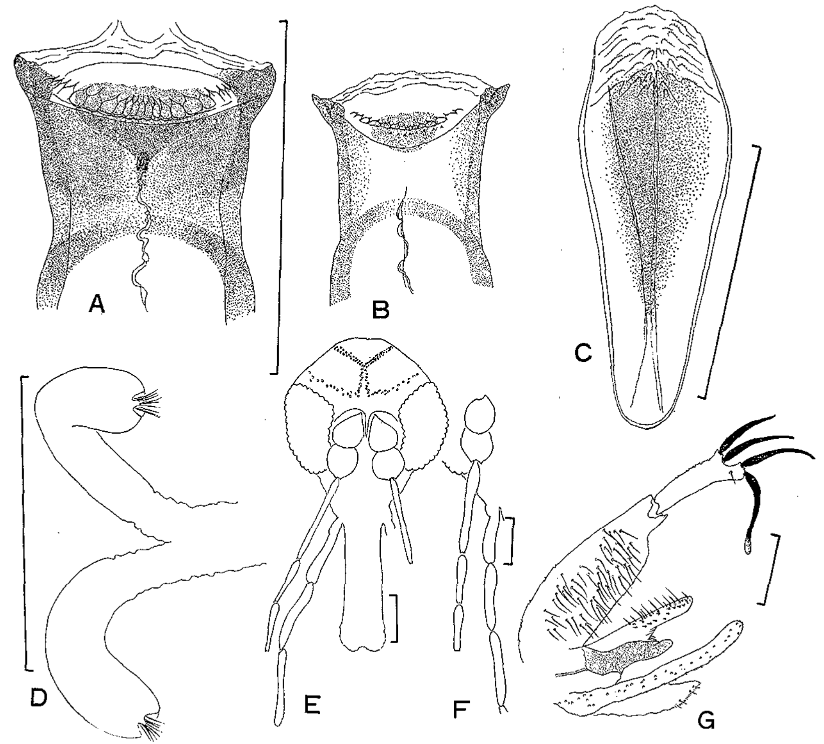

Fig. 17. *Phlebotomus schwetzi.* a, ♀ cibarium; b, ♂ cibarium; c, ♀ pharynx; d, ♀ spermathecae; e, ♀ head; f, ♂ antenna base and palp; g, ♂ genitalia.

darkened centrally, with setose, scale-like folds apically but lacking spines. Clypeus flattened or with median concavity on anterior margin; epipharynx 1.1–1.4 length of antenna segment 3. Antenna with segment 3 shorter than 4+5 combined, rarely equal in length, extending to distal 3/4 of palpal segment 2 (fig. 17e); ascoids paired on segments 3–15, 0.4–0.6 length of segment 4. Palpal formula 1–2–(4–3)–5, average ratio=13: 14: 13.5: 33 but variable, segment 4 often equal to or longer than 3; segment 3 with large patch of Newstead scales near base. Wing with R_{2+3} 1–2× length of R_2, R_1 apex (delta) 0.3–0.5 length of R_2. Tergite 6 often and 5 sometimes with single row of few, large sockets which apparently bore erect hairs. Spermatheca (fig. 17d) tubular, scarcely differentiated from short, thick duct; apical knob deeply withdrawn.

Measurements: Antenna 3=0.16±0.01 mm (0.14–0.19); 4+5 = 0.18 ± 0.01 mm (0.16–0.20). Epipharynx=0.21±0.01 mm (0.19–0.24). Wing length=1.86+0.1 mm (1.60–2.12); width=0.44±0.05 mm (0.36–0.58). 50 specimens.

♂. Cibarium (fig. 17b) armed with 14–19 teeth similar to ♀, but smaller and 3–4 central teeth slightly reduced, 6–10 small, indistinct erect teeth; pigment patch elliptical, more distinct than in ♀ as ventral wall less heavily pigmented; chitinous arch well developed. Pharynx more slender than in ♀. Epipharynx subequal in length to antenna segment 3. Antenna segments 3,4,5 little longer than in ♀; ascoids single on segments 3–15, 0.3–0.4 length of 4. Tergite 6 equal to or little smaller than 5. Genitalia (fig. 17g): Dististyle with 2 apical spines and 2 at distal 3/4 on prominent tubercle, seta between pairs of spines; basistyle with many nondeciduous hairs on inner face; aedeagus thick, slightly curved, apex bluntly rounded, subapical dorsal notch marking exit of filaments; genital filaments 3.5–5× pump length.

Measurements: Antenna 3=0.18±0.01 mm (0.16–0.21); 4+5=0.20±0.01 mm (0.18–0.22). Epipharynx =0.17±0.01 mm (0.14–0.20). Wing length = 1.65 ± 0.08 mm (1.38–1.84); width=0.34±0.03 mm (0.25–0.42). 50 specimens.

Types: ♂, ♀, Stanleyville, Congo; Hebrew Univ., Israel.

Distribution: Algeria, Mali, Senegal, Guinea, Ghana, Nigeria, Chad, Cameroon, Congo, Sudan, Eritrea, Ethiopia, Uganda, Kenya, S. Africa, Saudi Arabia.

Sudan: Kassala, Kordofan, Blue Nile, Upper Nile, Equatoria Provinces.

P. schwetzi is easily distinguished in both sexes from other species in the area by the cibarial teeth and uncurved sides of the pharynx. The ♀ spermatheca is not unlike that of *antennatus* and *bedfordi*. The ♂ genitalia, with the pair of spines well removed from the apex of the dististyle and the thick, blunt aedeagus, is distinctly different from other ♂♂.

Types of *symesi* and topotypes of *aethiopicus* were studied and the synonymy of these forms with *schwetzi* was confirmed.

Phlebotomus (Sergentomyia) africanus Newstead Fig. 18.

Phlebotomus minutus var. *africanus* Newstead, 1912, Bull. Ent. Res. **3**: 361.

Phlebotomus africanus: Adler, Theodor, & Parrot, 1929, Rev. Zool. Bot. Afr. **18**: 73. Parrot, 1930, *Ibid.* **19**: 181. Theodor, 1938, Bull. Ent. Res. **29**: 166. DeMeillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 38. Rageau, 1951, Bull. Soc. Path. Exot. **44**: 794. Parrot & Martin, 1945, Arch. Inst. Pasteur Alg. **23**: 279. Kirk & Lewis, 1953, Ann. Trop. Med. Parasit. **47**: 126.

Phlebotomus (Prophlebotomus) africanus: Parrot, 1937, Arch. Inst. Pasteur Alg. **15**: 119. Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 628; Parrot & Malbrant, 1945, Arch. Inst. Pasteur Alg. **23**: 121. Parrot, Mornet & Cadenat, 1945, *Ibid.* **23**: 239, 281. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 44; 1948, *Ibid.* **42**: 325. Parrot, 1948, Arch. Inst. Pasteur Alg. **26**: 270. Rageau & Adam, 1953, Bull. Soc. Path. Exot. **46**: 587.

Sergentomyia (Sergentomyia) africana: Theodor, 1948, Bull. Ent. Res. **39**: 110.

Sergentomyia (Parrotomyia) africana: Theodor, 1958, Flieg. Pal. Reg., Lief 201, p. 42. Lewis & Kirk, 1960, Ann. Mag. Nat. Hist., ser. 13, **3**: 238. Qutubuddin, 1962, *Ibid.*, ser. 13, **3**: 595.

Phlebotomus africanus var. *magnus* Sinton, 1932, Ind. Jour. Med. Res. **20**: 565. (Types: Transvaal; BMNH). De Meillon and Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 39. Synonymy cited by Theodor, 1958: 42.

Phlebotomus (Prophlebotomus) africanus var. *magnus*: Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 45.

Sergentomyia (Parrotomyia) africanus magnus: Lewis & Kirk, 1960, Ann. Mag. Nat. Hist., ser. 13, **3**: 238.

Phlebotomus (Sergentomyia) freetownensis var. *magnus*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 472.

Phlebotomus freetownensis var. *magnus*: Abonnenc, 1956, Arch. Inst. Pasteur Alg. **34**: 388.

Phlebotomus freetownensis magnus: De Meillon & Hardy, 1953, Jour. Ent. Soc. S. Afr. **16**: 32. Abonnenc, 1962, Arch. Inst. Pasteur Alg. **40**: 220.

Phlebotomus (Sergentomyia) freetownensis magnus: Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 637.

Phlebotomus africanus var. *sudanicus* Theodor, 1933,

Bull. Ent. Res. **24**: 541. (Types: Sudan; Hebrew Univ., Jerusalem). De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 39. Parrot, Mornet & Cadenat, 1945, Arch. Inst. Pasteur Alg. **23**: 239. Rageau, 1951, Bull. Soc. Path. Exot. **44**: 794. Abonnenc, 1956, Arch. Inst. Pasteur Alg. **34**: 392. Synonymized with *magnus* by Lewis & Kirk, 1960.

Phlebotomus (*Prophlebotomus*) *africanus* var. *sudanicus*: Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 629; 1946a, Ann. Trop. Med. Parasit. **40**: 45; 1948, *Ibid.* **42**: 325.

Phlebotomus (*Sergentomyia*) *freetownensis* var. *sudanicus*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 477. Kirk & Lewis, 1952, Ann. Trop. Med. Parasit. **46**: 346.

Phlebotomus freetownensis var. *sudanicus*: Abonnenc, 1956, Arch. Inst. Pasteur Alg. **34**: 392.

Phlebotomus (*Prophlebotomus*) *africanus* var. *longior* Parrot, 1936, Arch. Inst. Pasteur Alg. **14**: 40 (Types: Ethiopia; IPA). Parrot, 1937, *Ibid.* **15**: 119. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 44. Synonymized with *magnus* by Abonnenc, 1956.

Phlebotomus africanus var. *longior*: Parrot, 1938, Arch. Inst. Pasteur Alg. **16**: 213. DeMeillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 39.

Phlebotomus (*Sergentomyia*) *freetownensis* var. *longior*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 475.

Phlebotomus (*Prophlebotomus*) *africanus* var. *ater* Parrot, 1936a Arch. Inst. Pasteur Alg. **14**: 43. (Types: Ethiopia; IPA.). Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. 40: 44. **New synonymy.**

Phlebotomus africanus var. *ater*: DeMeillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 39.

Phlebotomus (*Sergentomyia*) *freetownensis* var. *ater*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 474.

Sergentomyia (*Parrotomyia*) *africanus* var. *atra*: Lewis & Kirk, 1960, Ann. Mag. Nat. Hist., ser. 13, **3**: 238.

Phlebotomus africanus var. *niger* Parrot & Schwetz, 1937, Rev. Zool. Bot. Afr. **29**: 221. (Types: Congo Rep.; Mus. Roy. Afr. Cent.). Theodor, 1938, Bull. Ent. Res. **29**: 166. DeMeillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 39. Parrot, Mornet, & Cadenat, 1945, Arch. Inst. Pasteur Alg. **23**: 239. Parrot & Malbrant, 1945, *Ibid.* **23**: 121. Synonymy after Lewis & Kirk, 1960.

Phlebotomus (*Prophlebotomus*) *africanus* var. *niger*: Parrot, Mornet, & Cadenat, 1945, Arch. Inst. Pasteur Alg. **23**: 281. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 45; 1948, Ann. Trop. Med. Parasit. **42**: 325. Parrot, 1948, Arch. Inst. Pasteur Alg. **26**: 270. Rageau, 1951, Bull. Soc. Path. Exot. **44**: 793. Rageau & Adam, 1953, *Ibid.* **46**: 587.

Phlebotomus (*Sergentomyia*) *freetownensis* var. *niger*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 477; 1952, Ann. Trop. Med. Parasit. **46**: 345.

Phlebotomus freetownensis niger: Abonnenc, 1962, Arch. Inst. Pasteur Alg. **40**: 220.

Phlebotomus (*Prophlebotomus*) *eremitis* Parrot & Joliniere, 1945, Arch. Inst. Pasteur Alg. **23**: 56. (Types: Hoggar, Algeria; IPA). Parrot, 1946, Arch. Inst. Pasteur Alg. **24**: 70; 1948, *Ibid.* **26**: 270. Kirk & Lewis, 1948. Ann. Trop. Med. Parasit. **42**: 323. **New synonymy.**

Phlebotomus (*Sergentomyia*) *freetownensis* var. *eremitis*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 474.

Sergentomyia (*Sergentomyia*) *africanus* var. *eremitis*: Theodor, 1948, Bull. Ent. Res. **39**: 110.

Sergentomyia (*Parrotomyia*) *africana eremitis*: Theodor, 1958, Flieg. Pal. Reg., Lief. 201, p. 43. Lewis & Kirk, 1960, Ann. Mag. Nat. Hist., ser. 13, **3**: 238.

Phlebotomus(*Sergentomyia*) *freetownensis furanus*: Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 637. (Holotype, Sudan; BMNH). Synonymized with *P. a. magnus* by Lewis & Kirk, 1960.

Phlebotomus freetownensis Sinton, 1930, Ind. Jour. Med. Res. **18**: 171. (Holotype, Sierra Leone; BMNH). DeMeillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 40. Abonnenc, 1956, Arch. Inst. Pasteur Alg. **34**: 388.

Phlebotomus (*Prophlebotomus*) *freetownensis*: Parrot, 1946, Arch. Inst. Pasteur Alg. **24**: 70. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 45.

Phlebotomus (*Sergentomyia*) *freetownensis*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 472; 1952, Ann. Trop. Med. Parasit. **46**: 345.

Sergentomyia (*Parrotomyia*) *freetownensis*: Lewis & Kirk, 1960, Ann. Mag. Nat. Hist., ser. 3, **3**: 238.

Medium-sized species with comb-like cibarial teeth and light patch of apical setae in pharynx.

♀. Cibarium (fig. 18a) armed with row of 25–54 comb-like teeth in even, concave row, 7–14 erect teeth; ventral wall weakly concave posteriorly, pigmented from arch to posterior margin, dark brown to black on posterior margin; pigment patch dark (sometimes black), crescent-shaped with lighter colored, slender anterior projection; chitinous arch weak or lacking. Pharynx (fig. 18b) constricted posteriorly into collar-like apex, with light cluster of apical setae. Epipharynx little longer than antenna segment 3. Antenna with segment 3 of moderate length, little shorter than 4+5 combined, extending to about distal 2/3 of palpal segment 2 (fig. 18f); ascoids paired on segments 3–15, 0.3–0.4 length of segment 4. Palpal formula 1–2–3–4–5, ratio=10: 12: 14: 28, segment 3 with patch of Newstead scales near base, patch about 1/5 length of segment. Wing (fig.

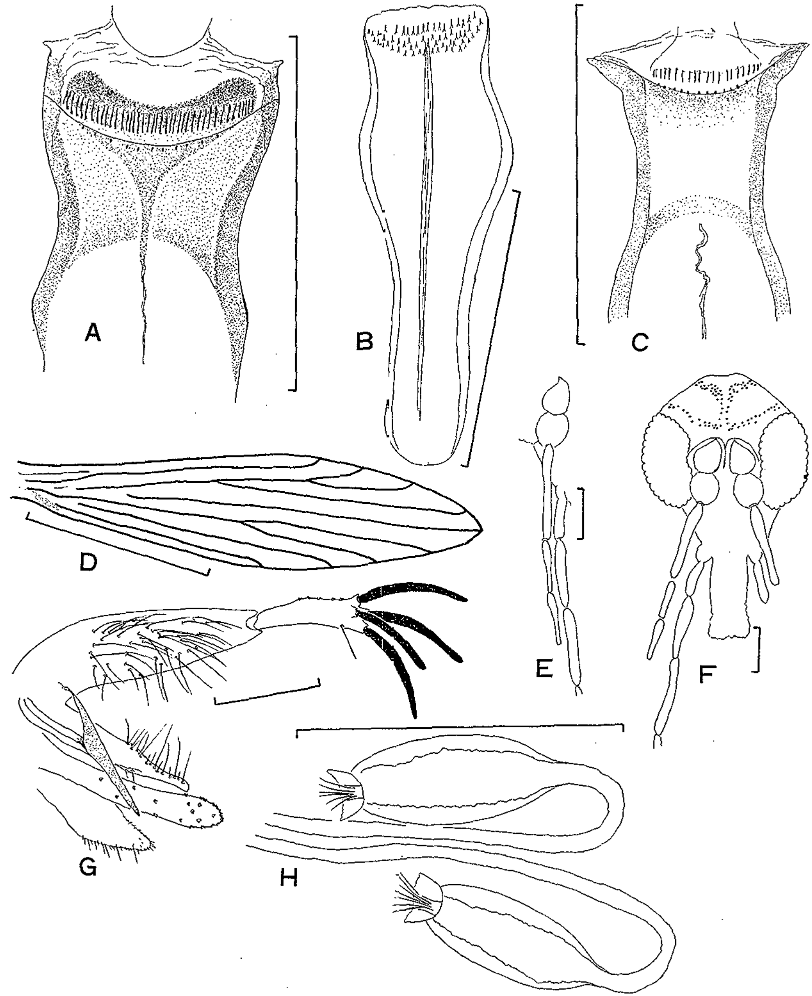

Fig. 18. *Phlebotomus africanus*. a, ♀ cibarium; b, ♀ pharynx; c, ♂ cibarium; d, ♀ wing; e, ♂ antenna base and palp; f, ♀ head; g, ♂ genitalia, lateral view; h, ♀ spermatheca.

18d) with R_{2+3} usually 1.5× R_2, R_1 apex (delta) 1/4–1/2 length of R_2. Spermatheca (fig. 18h) capsular with smooth outer wall and thinner, wrinkled inner wall, apical knob surrounded by collar, ducts long and slender.

Measurements: Antenna 3=0.16±0.03 mm (0.13–0.18); 4+5=0.17±0.03 mm (0.15–0.19). Epipharynx =0.17±0.01 mm (0.14–0.19). Wing length=1.64±0.1 mm (1.30–1.83); width=0.39±0.03 mm (0.31–0.47). 100 specimens.

♂. Cibarium (fig. 18c) armed with 14–24 comb-like teeth, smaller than in ♀, 4–12 erect teeth; pigment patch indistinct or absent; chitinous arch moderately to well developed. Pharynx slender, with small denticles and without setae. Epipharynx shorter than antenna segment 3. Antennal segments 3,4,5 little longer than in ♀; ascoids single on segments 3–15, 0.2–0.3 length of segment 4. Tergites 5 & 6 subequal in size. Genitalia (fig. 18g): Dististyle with 2 apical and 2 subapical spines, seta at distal 3/5 or 3/4; basistyle with many nondeciduous hairs on inner face; aedeagus slender, tapering to sharp apex, filaments 3–4× pump length; paramere ending in beak-like apex, shorter than lateral lobe.

Measurements: Antenna 3=0.17±0.01 mm (0.14–0.21); 4+5 = 0.19 ± 0.02 mm (0.16–0.23). Epipharynx=0.15±0.01 mm (0.12–0.19). Wing length =1.58±0.1 mm (1.35–1.83); width=0.34±0.03 mm (0.28–0.40). 100 specimens.

Lectotype: ♀, Onitsha (Niger R.), Nigeria; BMNH, selected by Lewis & Kirk, 1960.

Distribution: Algeria, Morocco, Mali, Senegal, Guinea, Sierra Leone, Ghana, Dahomey, Nigeria, Cameroon, Congo (French), Congo Rep. (Belg.), Sudan, Eritrea, Ethiopia, Uganda, Kenya, So. Africa.

Sudan: Probably throughout, recorded in all provinces except Northern, Khartoum and Bahr el Ghazal.

P. africanus is a widespread, common African species recognized by the row of comb-like teeth over a dark, crescent or sausage-shaped pigment patch and pharynx with the constricted apex in the form of a collar. In the Sudan ♀♀ are unlikely to be confused with other species, but the ♂ genitalia is similar to that of *clydei*. These two are separable by the shape of the pharynx, structure of the cibarial teeth (under high magnification) and the enlarged tergite 6 (in the Paloich area, at least) of *clydei*.

There is considerable variation in the taxonomic characters of *africanus*. For example, there may be as many as 70 cibarial teeth in the ♀ and 35 in the ♂ and palpal segments 3 & 4 may be equal or subequal. The taxonomy of the species has been complicated by the naming of a number of these varieties. Some of these have now been recognized as individual variants and suppressed as indicated in the synonymical bibliography above and others are being suppressed at this time.

Several of the named varieties of *africanus* have been elevated to subspecific rank (Theodor 1958; Lewis & Kirk 1960), but evidence does not support this conclusion and I regard the following as outright synonyms of *africanus*:

The characters of *magnus* fall within the range of *africanus* variation. Specimens assigned to this variety are widespread in Africa without geographical segregation and do not indicate a subspecific pattern. The discontinuity and character intergradation in various parts of the range of *africanus* has been noted by Abonnenc & Larivière (1959) and Lewis & Kirk (1960). I conclude that the name *magnus* should be suppressed as a synonym of *africanus*.

The types of *ater* (Ethiopia), *eremitis* (Algeria, Sudan), *longior* (Ethiopia), and *niger* (Mali, Guinea, Ivory Coast, Dahomey, Nigeria, Cameroon, Congo, Uganda) were studied at Algiers. *P. ater* and *longior* fall within the variation range of Paloich specimens. The cibarial teeth of *eremitis* are larger and more numerous than of Paloich specimens and the accessory seta of the dististyle(in the ♂ type) is near the center; palpus segment 4 is longer than 3 in both types, instead of subequal as stated by Parrot & Joliniere (1945). *P. niger* has a heavily pigmented pigment patch and eyes, also, are very dark. These differences do not seem significant and at present, there is no evidence for geographic segregation. None of these named variants, in my opinion, warrant nomenclatorial recognition and the four are synonymized with *africanus*.

Phlebotomus (Sergentomyia) antennatus Newstead Fig. 19.

Phlebotomus antennatus Newstead, 1912, Bull. Ent. Res. **3**: 365. Kirk & Lewis, 1949, Ann. Trop. Med. Parasit. **43**: 334. Parrot, 1951b, Arch. Inst. Pasteur Alg. **29**: 130. Parrot & Bellon, 1952, *Ibid.* **30**: 61. Abonnenc, 1958, *Ibid.* **36**: 315; 1962, *Ibid.* **40**: 220.

Phlebotomus (*Prophlebotomus*) *antennatus*: Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 47. Parrot & Clastrier, 1956, Arch. Inst. Pasteur Alg. **34**: 513.

Phlebotomus (*Sergentomyia*) *antennatus*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 452; 1952, Ann. Trop. Med. Parasit. **46**: 342. Heisch, Guggisberg & Teesdale, 1956, Trans. R. Soc. Trop. Med. Hyg. **50**: 213. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 636.

Sergentomyia (*Sergentomyia*) *antennata*: Theodor, 1948, Bull. Ent. Res. **39**: 108; 1958, Flieg. Pal. Reg., Lief. 201, p. 27. Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 595.

Phlebotlmus minutus var. *antennatus*: Parrot, 1930, Rev. Zool. Bot. Afr. **19**: 189. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 41.

Phlebotomus signatipennis Newstead, 1920, Bull. Ent. Res. **11**: 305 (Type: ♀, Ghana; BMNH). Parrot & Joliniere, 1945, Arch. Inst. Pasteur Alg. **23**: 56. Synonymy by Parrot, 1951.

Phlebotomus (*Prophlebotomus*) *signatipennis*: Parrot, Mornet & Cadenat, 1945, Arch. Inst. Pasteur Alg. **23**: 239, 286. Parrot, 1948, *Ibid.* **26**: 259; 1946, *Ibid.* **24**: 69. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 46; 1948, *Ibid.* **42**: 325.

Phlebotomus minutus var. *signatipennis*: Theodor, 1938, Bull. Ent. Res. **29**: 172. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 41. Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 628. Parrot, 1942, Arch. Inst. Pasteur Alg. **20**: 323.

Phlebotomus (*Sergentomyia*) *antennatus* var. *signatipennis*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 454.

Phlebotomus antennatus var. *signatipennis*: Rageau, 1951, Bull. Soc. Path. Exot. **44**: 794.

Phlebotomus sanneri Galliard & Nitzulescu, 1931, Ann. Parasit. Hum. Comp. **9**: 233. Parrot, 1938, Arch. Inst. Pasteur Alg. **16**: 213. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 42. Synonymy after Parrot, 1942.

Phlebotomus (*Prophlebotomus*) *sanneri*: Parrot, 1936,

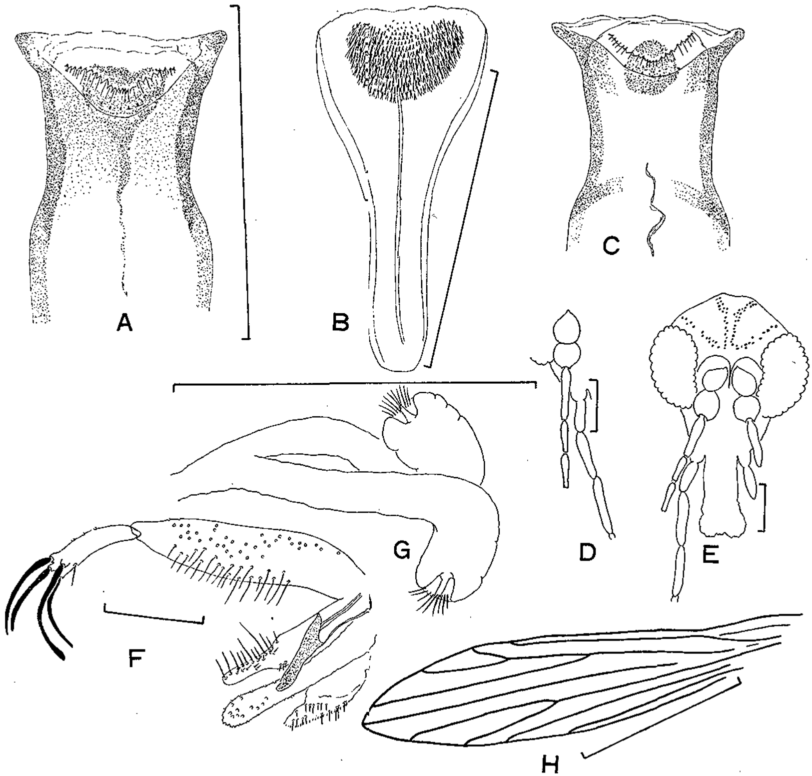

Fig. 19. *Phlebotomus antennatus*. a, ♀ cibarium; b, ♀ pharynx; c, ♂ cibarium; d, ♂ antenna base and palp; e, ♀ head; f, ♂ genitalia, lateral view; g, ♀ spermatheca; h, ♀ wing.

Arch. Inst. Pasteur Alg. **14**: 45; 1937, *Ibid.*, **15**: 117.

Phlebotomus minutus var. *occidentalis* Theodor, 1933, Bull. Ent. Res. **24**: 539. DeMeillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 41. (Types: Ghana; BMNH). **New synonymy.**

Phlebotomus (*Prophlebotomus*) *occidentalis*: Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 48. Parrot, 1946, Arch. Inst. Pasteur Alg. **24**: 69; 1948, *Ibid.*, **26**: 262. Kirk & Lewis, 1948, Ann. Trop. Med. Parasit. **42**: 325.

Phlebotomus (*Sergentomyia*) *antennatus* var. *occidentalis*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**:455; 1952, Ann. Trop. Med. Parasit. **46**:343.

Phlebotomus (*Prophlebotomus*) *cinctus* Parrot & Martin, 1944, Arch. Inst. Pasteur Alg. **22**: 56. (Types: French Somaliland. IPA). Parrot, 1946, *Ibid.*, **24**: 72. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 47; 1948, *Ibid.*, **42**: 325. Parrot, 1948, Arch. Inst. Pasteur Alg. **26**: 265. **New synonymy.**

Phlebotomus (*Prophlebotomus*) *antennatus* var. *cinctus*: Parrot & Clastrier, 1960, Arch. Inst. Pasteur Alg. **38**: 75.

Phlebotomus (*Sergentomyia*) *antennatus* var. *cinctus*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 456; 1952, Ann. Trop. Med. Parasit. **46**: 342.

Sergentomyia (*Sergentomyia*) *cincta*: Theodor, 1958, Flieg. Pal. Reg., Lief. 201, p. 38.

Small, dark species with dark cibarial pigment patch and heavy cluster of apical spines in pharynx.

♀. Cibarium (fig. 19a) armed with row of 18–30 palisade-like teeth, median and few lateral ones smaller than others, median teeth more closely packed and do not extend as high as others, sometimes 6–8 small, indistinct erect teeth; margin of ventral wall usually deeply concave leaving a hemispherical clear area below teeth; pigment patch very dark with black anterior part, obscuring teeth (except in well cleared specimens), hemispherical with rounded or trinodal posterior margin, anterior projection slender; chitinous arch lacking. Pharynx (fig. 19b) strongly expanded posteriorly, maximum width averages 2.6 (1.7–4.1) minimum width; dense, conspicuous cluster of spines apically. Epipharynx 1.4–2.0× length of antenna segment 3. Antenna with segment 3 very short, shorter than 4+5, extending to base of palpal segment 2 (fig. 19c); ascoids paired on segments 3–15, about 1/2 length of segment 4. Palpal formula usually 1–2–(3–4)–5, rarely segment 4 longer than 3, palpal ratio usually 10: 11: 11: 24; segment 3 with large patch of Newstead scales near base, patch about 1/5 length of segment. Wing (fig. 19h) with R_{2+3} usually 2× length of R_2, R_1 usually ends at level of fork. Spermatheca (fig. 19g) tubular, differentiated from short duct by slight expansion, with few weak annulations; apical knob deeply withdrawn.

Measurements: Antenna 3=0.09±0.01 mm (0.08–0.11); 4+5=0.11±0.01 mm (0.10–0.12). Epipharynx =0.15±0.01 mm (0.13–0.16). Wing length=1.54±0.09 (1.38–1.76); width=0.33±0.04 mm (0.25–0.36). 50 specimens.

♂. Cibarium (fig. 19c) armed with 15–25 teeth, smaller and less distinct than in ♀, 8–12 erect teeth, more distinct than in ♀, sometimes second row of about 6 erect teeth; pigment patch dark, roughly circular, without anterior projection. Pharynx slender, with small denticles and without large spines. Epipharynx 1.1–1.5× length of antenna segment 3. Antennal segments 3, 4, 5 little longer than in ♀; ascoids single on segments 3–15, about 1/3 length of segment 4. Tergites 5 & 6 subequal in size. Genitalia (fig. 19f): Diststyle with 2 apical and 2 subapical spines, seta at distal 3/4; basistyle with few nondeciduous hairs on inner face; aedeagus rounded at apex, slightly swollen distally and with notch on upper margin marking exit of genital filaments, filaments 3—3.5×pump length; paramere bluntly rounded at apex, shorter than lateral lobe.

Measurements: Antenna 3=0.11±0.01 mm (0.09–0.12); 4+5=0.14±0.01 mm (0.12–0.16). Epipharynx =0.14±0.01 mm (0.12–0.16). Wing length=1.49±0.06 (1.32–1.57); width=0.26±0.02 mm (0.23–0.31). 50 specimens.

Holotype: ♀, Ghana (Gold Coast); BMNH.

Distribution: Algeria, Mali, Senegal, Ivory Coast, Ghana, Dahomey, Nigeria, Chad, Cameroon, Sudan, Eritrea, Ethiopia, French Somaliland, Somalia, Gabon, Congo, Uganda, Kenya.

Sudan: Probably throughout; recorded in all provinces except Khartoum and Bahr el Ghazal.

P. antennatus is easily recognized by the short antennal segment 3 in both sexes, the very dark pigment patch and heavily spined pharynx in the ♀, and blunt-tipped aedeagus and lateral lobe of the ♂. It may be confused with *bedfordi*, but the indented margins of the pharynx, readily distinguishes *bedfordi* ♀♀ from *antennatus* ♀♀; see *bedfordi* for further details.

The variety *occidentalis* (Sudan, Nigeria, Ghana) is characterized by 26–32, equal teeth on an arc less concave than in others and palpal formula 1–2–(4–3)–5. These variations are found in the Paloich specimens. This, along with the discontinuous distribution of *occidentalis* throughout the range of *antennatus*, leads me to the conclusion that *occidentalis* is merely individual variation and should not be recognized nomenclatorially. ♀ and ♂ cotypes were studied at the BMNH.

The variety *cinctus* (Sudan, French Somaliland, Uganda) is somewhat smaller than any Paloich speci-

mens with a wing length of 1.35–1.50 mm and has fewer cibarial teeth, 14–20. It was also characterized by 5–8 erect teeth and a narrow pharynx with maximum width 3× the minimum. The range in size overlaps and the number of erect teeth and shape of pharynx are found in Paloich populations. The variety seems to include some small individuals of *antennatus*, but do not appear to differ enough to warrant subspecific or other nomenclatorial recognition. The type of *cinctus* in Algiers was studied.

Phlebotomus (Sergentomyia) bedfordi Newstead, Fig. 20.

Phlebotomus bedfordi Newstead, 1914, Bull. Ent. Res. **5**: 191. Parrot, 1921, Arch. Inst. Pasteur Afr. Nord **1**: 269. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 39. Kirk & Lewis, 1949, Ann. Trop. Med. Parasit. **43**: 333. Rageau, 1951, Bull. Soc. Path. Exot. **44**: 795. Abonnenc, 1962, Arch. Inst. Pasteur Alg. **40**: 220.

Phlebotomus (*Prophlebotomus*) *bedfordi*: Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 45.

Phlebotomus (*Sergentomyia*) *bedfordi*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 458; 1952, Ann. Trop. Med. Parasit. **46**: 343. Heisch, Guggisberg & Teesdale, 1956, Trans. R. Soc. Trop. Med. Hyg. **50**: 213. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 636.

Sergentomyia (*Sergentomyia*) *bedfordi*: Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 595.

Phlebotomus africanus var. *congolensis* Bequaert & Walravens, 1930, Rev. Zool. Bot. Afr. **19**: 38 (Types: Congo; Mus. Roy. Afr. Centr., Tervueren). Parrot, 1933, Rev. Zool. Bot. Afr. **23**: 239. **New synonymy.**

Phlebotomus congolensis: Parrot & Martin, 1939, Arch. Inst. Pasteur Alg. **17**: 155. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 39, 43.

Phlebotomus (*Prophlebotomus*) *congolensis*: Parrot, 1937, Arch. Inst. Pasteur Alg. **15**: 118. Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 630; 1946a, Ann. Trop. Med. Parasit. **40**: 48. Parrot, 1946, Arch. Inst. Pasteur Alg. **24**: 69.

Phlebotomus bedfordi var. *congolensis*: Kirk & Lewis, 1949, Ann. Trop. Med. Parasit. **43**: 334. Rageau, 1951, Bull. Soc. Path. Exot. **44**: 795.

Phlebotomus bedfordi congolensis: De Meillon & Hardy, 1953, Jour. Ent. Soc. S. Afr. **16**: 32. Abonnenc, 1962, Arch. Inst. Pasteur Alg. **40**: 220.

Phlebotomus (*Sergentomyia*) *bedfordi* var. *congolensis*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 459; 1952, Ann. Trop. Med. Parasit. **46**: 343. Heisch, Guggisberg & Teesdale, 1956, Trans. R. Soc. Trop. Med. Hyg. **50**: 213. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 636.

Phlebotomus nairobiensis Theodor, 1931, Bull. Ent. Res. **22**: 472 (Types: Kenya; Hebrew Univ.). Synonymized with *bedfordi* var. *congolensis* by Kirk & Lewis, 1951.

Phlebotomus congolensis var. *distinctus* Theodor, 1933. Bull. Ent. Res. **24**: 542; 1938, *Ibid.* **29**: 172 [Types: Gold Coast; BMNH (& Hebrew Univ.?)]. Synonymy after Kirk & Lewis, 1949.

Phlebotomus (*Prophlebotomus*) *congolensis* var. *distinctus*: Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 630. Parrot, Mornet & Cadenat, 1945, Arch. Inst. Pasteur Alg. **23**: 241, 281. Parrot, 1946, *Ibid.* **24**: 69. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 48; 1948, *Ibid.* **42**: 325. Parrot, 1948, Arch. Inst. Pasteur Alg. **26**: 271.

Phlebotomus (*Prophlebotomus*) *congolensis* var. *firmatus* Parrot & Malbrant, 1945, Arch. Inst. Pasteur Alg. **23**: 122. (Types: Congo; IPA). Parrot, 1946, *Ibid.* **24**: 70. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 48. **New synonymy.**

Phlebotomus bedfordi var. *firmatus*: Kirk & Lewis, 1949, Ann. Trop. Med. Parasit. **43**: 333. Rageau, 1951, Bull. Soc. Path. Exot. **44**: 794.

Phlebotomus (*Sergentomyia*) *bedfordi* var. *firmatus*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 460.

Phlebotomus cowlandi Lewis & Kirk, 1946, Proc. R. Ent. Soc. Lond. ser. B, **15**: 155. (Holotype: ♂, Sudan; BMNH). Synonymized with *bedfordi* var. *congolensis* by Lewis & Kirk, 1957.

Phlebotomus (*Prophlebotomus*) *cowlandi*: Kirk & Lewis, 1948, Ann. Trop. Med. Parasit. **42**: 323.

Phlebotomus (*Sergentomyia*) *cowlandi*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 462.

Phlebotomus (*Sergentomyia*) *bedfordi* var. *bereiri* Kirk & Lewis, 1952, Ann. Trop. Med. Parasit. **46**: 343. (Holotype, ♀, Sudan; BMNH). Lewis & McMillan, 1961, Proc. R. Ent. Soc. Lond. ser. B, **30**: 30. **New synonymy.**

Medium-sized, moderately dark species with sharp, spike-like teeth, large, black pigment patch and pharynx constricted laterally and with dense cluster of spines.

♀. Cibarium (figs. 20a,b) with row of 20–44 sharply pointed, spike-like teeth in concave row, central ones equal sized or smaller and more compact than lateral ones, as many as 24 erect teeth, small and indistinct, located on ridge at base of horizontal teeth; ventral wall weakly concave posteriorly, pigmented posteriorly and fading out anteriorly; pigment patch black (obscuring teeth except in well cleared specimens), ovoid with ragged posterior margin and sometimes with short, tapering anterior projection which may be thick and irregular at base; chitinous arch lacking. Pharynx (fig. 20c) gradually expanding posteriorly with lateral constriction at apical 3/4, pigmented centrally,

with large cluster of black, distal spines variable in number and density, setae at apex, maximum width 2–4× minimum. Epipharynx 1.2–1.5 length of antenna segment 3. Antenna with segment 3 shorter than 4+5 combined, extending to about middle of palpal segment 2 (fig. 20g); ascoids paired on segments 3–15, 0.3–0.6 length of segment 4. Palpal formula 1–2–3–4–5, ratio=10: 11: 14: 29; segment 3 with patch of Newstead scales near base. Wing with R_{2+3} 1.2–2.0× R_2, R_1 apex (delta) 0–0.4 length of R_2. Spermatheca tubular, differentiated from short duct only by slight expansion, with few weak annulations, indistinguishable from *antennatus*; apical knob deeply withdrawn.

Measurements: Antenna 3=0.12±0.01 mm (0.11–0.14); 4+5=0.15±0.02 mm (0.12–0.16). Epipharynx=0.16±0.01 mm (0.15–0.19). Wing length=1.70±0.1 mm (1.52–1.90); width=0.37±0.04 mm (0.31-0.44). 30 specimens.

♂. (partly after Kirk & Lewis, 1951), Cibarium (fig. 20d) armed with 14–35 spike-like teeth, smaller than in ♀, and 14–20 erect teeth on ridge as in ♀; pigment patch irregularly ovoid, sometimes absent; chitinous arch weakly developed. Pharynx slender, slightly flared out distally, darkened medially, with small denticles, lateral ones largest. Epipharynx equal to or little longer than antenna segment 3. Antennal segments 3, 4, 5 little longer than in ♀; ascoids single on segments 3–15, 0.2–0.4 length of segment 4. Tergites 5 & 6 subequal in size. Genitalia (fig. 20e): Dististyle with 2 apical and 2 subapical spines, seta at distal 4/5; basistyle with few nondeciduous hairs on inner face; aedeagus rounded at apex, slightly swollen distally and with notch on upper margin marking exit of genital filaments; filament about 4× pump length; paramere bluntly rounded at apex and slightly clavate, shorter than lateral lobe.

Measurements: Antenna 3=0.10–0.16 mm; 4+5=0.11–0.16mm. Epipharynx=0.13–0.18mm. Wing length

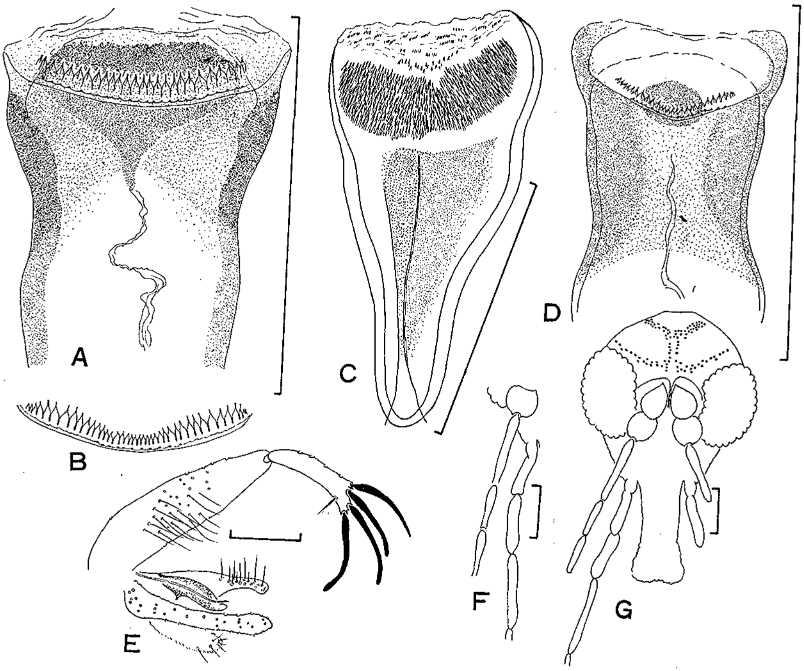

Fig. 20. *Phlebotomus bedfordi.* a, ♀ cibarium; b, ♀ cibarial teeth; c, ♀ pharynx; d, ♂ cibarium; e, ♂ genitalia, lateral view; f, ♂ antenna base and palp; g, ♀ head.

= 1.35–1.60 mm, width=0.28–0.40 mm. 2 specimens.

Type: ♀, Onderstepoort, Transvaal, So. Afr.; BMNH.

Distribution: Senegal, Guinea, Ghana, Dahomey, Niger, Nigeria, Cameroon, Congo, Sudan, Eritrea, Ethiopia, Kenya, Uganda, So. Rhodesia, Transvaal.

Sudan: Recorded in all provinces except Northern and Khartoum.

♀♀ of *bedfordi* are easily recognized by the spinose pharynx with indented margins and the large, black pigment patch of the cibarium. ♂♂ are similar to *antennatus*, but *bedfordi* is distinguished by the longer antennal 3 and palpal segments 3. In *bedfordi* the ratio of palpal segments 3 & 4 is usually 11: 14 and in *antennatus* 11: 11 or 11: 12. Paramere and aedeagus of *bedfordi* appear more curved than in *antennatus*, but I had only a few ♂♂ of the former and do not know if these differences are variable or constant

The black pigment patch obscures the cibarial teeth in specimens cleared in lacto-phenol, but clearing the head in KOH makes the teeth clearly visible without dissection. The number of teeth in the above description of the ♀ is based on specimens treated with KOH.

The named varieties of *bedfordi* are largely based on characters irregularly distributed through the range of *bedfordi* without showing geographical segregation. Even in the rather small series of *bedfordi* collected in the Paloich area, ♀♀ show a range which includes most of the named varieties.

The variety *congolensis* was separated by having 34–40 nearly uniform cibarial teeth and the degree of spination in the pharynx of the ♀ (and the relative length of the epipharynx and antennal segment 3 in the ♂). Variations in Paloich specimens show a continuous range in the ♀♀ which include those characters. A similar range was noted in Nigerian specimens by Lewis & McMillan (1961). The variety *congolensis* (Cameroon, Congo, Sudan, Eritrea, Ethiopia, E. Africa, Transvaal) is therefore suppressed as a synonym of *bedfordi*. This action also suppresses *nairobensis* and *cowlandi* which have been synonymized with *congolensis*.

Types of *firmatus* were studied. They have ascoids a little longer and the ♂ aedeagus thicker than Paloich *bedfordi*. These differences are not regarded as significant and *firmatus* is synonymized with *bedfordi*.

The synonymy of *bereiri* has been suggested by Lewis & McMillan (1961) after they found its distinguishing features of 22 equal cibarial teeth among other variations in Nigerian specimens. This feature is also present in Paloich populations and I propose suppressing *bereiri* as a synonym of *bedfordi*. The holotype was studied.

After studying types of *distinctus* and *cowlandi* I confirm the synonymy as given in the bibliography above.

Phlebotomus (Sergentomyia) squamipleuris Newstead Fig. 21.

Phlebotomus squamipleuris Newstead, 1912, Bull. Ent. Res. **3**: 366. Parrot, 1930, Rev. Zool. Bot. Afr. **19**: 182. Theodor, 1931, Bull. Ent. Res. **22**: 470. Parrot, 1933, Arch. Inst. Pasteur Alg. **11**: 603; 1938, *Ibid.* **16**: 217. Theodor, 1938, Bull. Ent. Res. **29**: 165. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 42, 44. De Meillon & Hardy, 1953, *Ibid.* **16**: 32.

Phlebotomus (*Prophlebotomus*) *squamipleuris*: Parrot, 1937, Arch. Inst. Pasteur Alg. **15**: 119. Kirk & Lewis, 1940, Trans. R. Soc. Trop. Med. Hyg. **33**: 630. Parrot & Martin, 1944, Arch. Inst. Pasteur Alg. **22**: 56. Parrot, Mornet & Cadenat, 1945, *Ibid.* **23**: 240. Parrot & Martin, 1945, *Ibid.* **23**: 279. Parrot, 1946, *Ibid.* **24**: 72. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 50; 1948, *Ibid.* **42**: 326. Parrot, 1948, Arch. Inst. Pasteur Alg. **26**: 270.

Phlebotomus (*Sergentomyia*) *squamipleuris*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 488; 1952, Ann. Trop. Med. Parasit. **46**: 346. Heisch, Guggisberg & Teesdale, 1956, Trans. R. Soc. Trop. Med. Hyg. **50**: 214. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist., ser. 12, **10**: 637. Quate, 1962, Pac. Ins. **4**: 259.

Sergentomyia (*Sergentomyia*) *squamipleuris*: Theodor, 1948, Bull. Ent. Res. **39**: 112.

Sergentomyia (*Grassomyia*) *squamipleuris*: Theodor, Flieg. Pal Reg. Lief. 201, p. 47. Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 595.

Phlebotomus squamipleuris var. *dreyfussi* Parrot, 1933, Arch. Inst. Pasteur Alg. **11**: 603 (Types: Algeria; IPA); 1936, *Ibid.* **14**: 46; 1938, *Ibid.* **16**: 217. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 43. **New synonymy.**

Phlebotomus (*Prophlebotomus*) *squamipleuris* var. *dreyfussi*: Ristorcelli, 1941, Arch. Inst. Pasteur Maroc, **2**: 521. Parrot, 1946, Arch. Inst. Pasteur Alg. **24**: 72. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 50. Parrot & Durand-Delacre, 1947, Arch. Inst. Pasteur Alg. **25**: 77. Parrot & Clastrier, 1960, *Ibid.* **38**: 75.

Phlebotomus (*Sergentomyia*) *squamipleuris* var. *dreyfussi*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 489.

Sergentomyia (*Grassomyia*) *squamipleuris dreyfussi*: Theodor, 1958, Flieg. Pal. Reg., Lief. 201, p. 47.

Phlebotomus squamipleuris var. *inermis* Theodor, 1938, Bull. Ent. Res. **29**: 165 (Types: Nigeria; Hebrew Univ., Jerusalem). Parrot & Martin, 1939, Arch. Inst. Pasteur Alg. **17**: 155. De Meillon & Lavoipierre, 1944, Jour. Ent. Soc. S. Afr. **7**: 43. **New synonymy.**

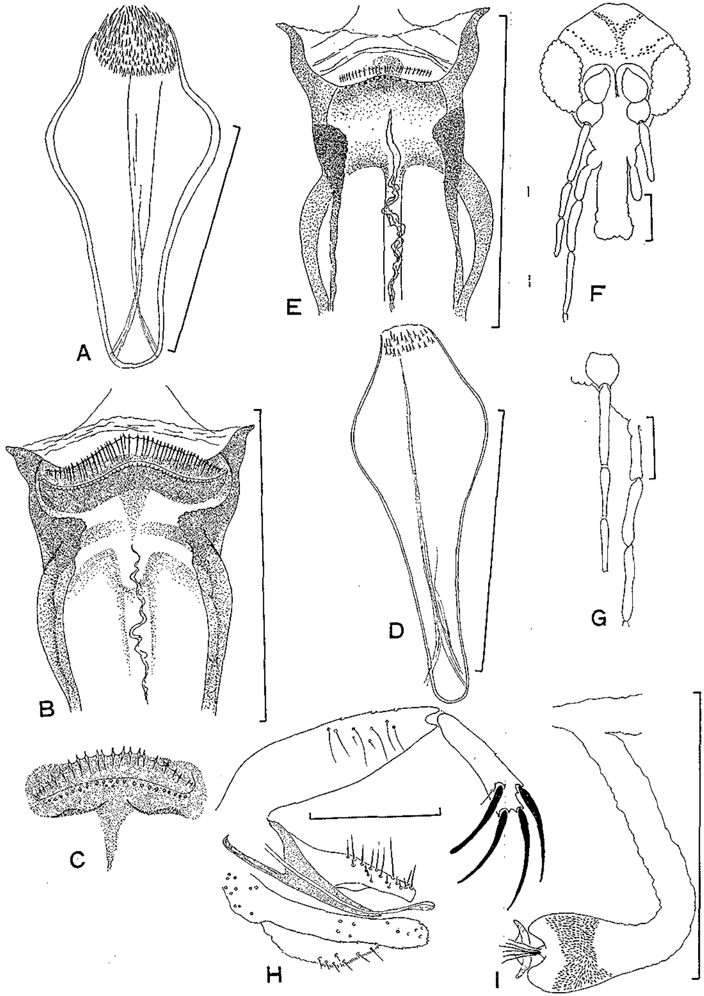

Fig. 21. *Phlebotomus squamipleuris*. a, ♀ pharynx; b, ♀ cibarium; c, ♀ cibarial teeth and pigment patch; d, ♀ pharynx (a variant); e, ♂ cibarium; f, ♀ head; g, ♂ antenna base and palp; h, ♂ genitalia, lateral view; i, ♀ spermatheca.

Phlebotomus (*Prophlebotomus*) *squamipleuris* var. *inermis*: Parrot, 1946, Arch. Inst. Pasteur Alg. **24**: 72. Kirk & Lewis, 1946a, Ann. Trop. Med. Parasit. **40**: 50; 1948, *Ibid*. **42**: 326.

Phlebotomus (*Sergentomyia*) *squamipleuris* var. *inermis*: Kirk & Lewis, 1951, Trans. R. Ent. Soc. Lond. **102**: 491; 1952, Ann. Trop. Med. Parasit. **46**: 346. Lewis & Kirk, 1957, Ann. Mag. Nat. Hist. ser. 12, **10**: 637.

Sergentomyia (*Grassomyia*) *squamipleuris inermis*: Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, **4**: 595.

Sergentomyia (*Grassomyia*) *squamipleuris haseebi* Qutubuddin, 1962, Ann. Mag. Nat. Hist., ser. 13, 4: 602 (Holotype: ♂, Sudan, BMNH). **New synonymy.**

Phlebotomus ghesquieri Parrot, 1929, Rev. Zool. Bot. Afr. **18**: 1. (Holotype, ♀: Congo Rep.; Mus. Roy. Afr. Centr.) Synonymy after Kirk & Lewis, 1951.

Medium-sized, dark species; cibarium with convex row of crown-like teeth, large, dark pigment patch and protuberant wall above arch.

♀. Cibarium (figs. 21b,c) with 24–60 large, sharply pointed, spike-like teeth in even, crown-like row and 20–50 erect teeth in convex row parallel to horizontal teeth, but often obscured by pigmentation; pigment patch large, black, nearly rectangular with short, thick anterior projection lighter in color: chitinous arch usually well developed; wall with jagged inward projection between arch and pigment patch. Pharynx (figs. 21a,d) lampglass-shaped, often broadly expanded posteriorly with variable apical armature from few small to many, moderately large and dark spines, pigmented centrally. Epipharynx 1.0–1.2 length of antenna segment 3. Antenna with segment 3 shorter than 4+5, extending to little beyond middle of palpal segment 2 (fig. 21f); ascoids absent from segment 3, single on 4–15, 0.4–0.6 length of segment 4. Palpal formula 1–2–3–4–5, average ratio=10:12:14.5:29; segment 2 with small patch of Newstead scales near center and segment 3 with larger patch near base. Wing with R_{2+3} little longer or shorter than R_2, R_1 apex (delta) usually 0.5–0.7 length of R_2. Thorax with few spatulate hairs on pleuron (in fresh specimens). Femora sometimes with rows of 4–9 small spines. Spermatheca (fig. 21i) globular, central band thickly setose, ducts short and thick; apex expanded into collar-like rim, knob withdrawn.

Measurements: Antenna 3=0.15±0.01 mm (0.13–0.17); 4+5=0.17±0.01 mm (0.15–0.19). Epipharynx =0.17±0.01 mm (0.15–0.19). Wing length=1.83±0.09 mm (1.68–2.03); width=0.42±0.03 mm (0.34–0.50). 50 specimens.

♂. Cibarium (fig. 21e) armed with 12–28 teeth similar to ♀, but smaller and less distinct, 12–20 erect teeth, but often indistinct or apparently absent; pigment patch variably shaped from ovoid to triangular with anterior projection or absent; chitinous arch well developed; walls with jagged projection like ♀ but smaller. Pharynx more slender than ♀, with apical setae. Epipharynx 0.9–1.2× antenna segment 3. Palpal segment 2 with few Newstead scales. Antenna segments 3, 4, 5 little longer than in ♀; ascoids absent from segment 3, single on 4–15, 0.3–0.6 length of segment 4. Tergite 6 usually 1.5–2.0× 5 in length and width, but few with tergites subequal. Genitalia (fig. 21h): Dististyle with 2 apical and 2 subapical spines, seta subapical or at distal 4/5; basistyle with few nondeciduous hairs on inner face; aedeagus tapering from distal 2/3 to rounded point; genital filaments 4–5× pump length, conspicuously expanded apically; paramere truncate apically.

Measurements: Antenna 3=0.15±0.01 mm (0.13–0.18); 4+5(0.17±0.01 mm (0.15–0.20). Epipharynx =0.15±0.01 mm (0.12–1.18). Wing length=1.64±0.09 mm (1.41–1.84); width=0.37±0.04 mm (0.28–0.42). 50 specimens.

Holotype: ♀, Khartoum, Sudan; BMNH.

Distribution: Algeria, Mali, Senegal, Ivory Coast, Dahomey, Nigeria, Congo, Sudan, Eritrea, Ethiopia, Kenya, Uganda, Mozambique, Madagascar, Iraq, India, Southeast Asia.

Sudan: Probably throughout, recorded in all provinces except Bahr el Ghazal.

P. squamipleuris is a distinctive species readily separated from other *Phlebotomus* species by its dark body color, the jagged inner protuberances of the cibarial wall, the crown-like row of teeth, dark pigment patch and unusual spermatheca of the ♀, and the genitalia, especially the inflated tips of the genital filaments, of the ♂. The presence of Newstead scales on the palpal segment 2 and spatulate hairs on the thoracic pleuron are often cited as distinctive features and while they are unique to the species, they are not easily seen.

Throughout its range, *squamipleuris* exhibits the same general features, but contrary to the statement of Lewis & Kirk (1949), there is considerable variation in certain structures (see Quate 1962, for variations of Indochinese *squamipleuris*). Several of these varieties in Africa have been named. The variety *dreyfussi* (east and northwest Africa) was separated on the basis of femoral spines, 42–45 cibarial teeth (the type has about 56 teeth) and wide pharynx in the ♀ and the antennal segment 3 being 0.23 mm with a concomitant larger ratio between it and the epipharynx in the ♂. The variety *inermis* (east and west Africa) was based on a small number, 20–24, teeth in the cibarium and slender pharynx with few, small apical spines. The subspecies *haseebi* (Sudan), based on a single ♂, was

characterized by the ♂ having 26 strong cibarial teeth, an oval pigment patch with conspicuous anterior projection and tergites 5 & 6 equal sized. Nearly all of these variations are included within the Paloich populations and appear to be within the normal range of individual variation of the species. The only exception to this is the long segment 3 of *dreyfussi*, but this character by itself is not adequate for a separate taxon. Except for *haseebi*, the distribution of the varieties are scattered through the range of the species. I believe that none exhibit features which justify separate names and *dreyfussi*, *inermis* and *haseebi* are suppressed as synonyms of *squamipleuris*.

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THREE NEW SPECIES OF *LEPTOTROMBIDIUM* (*LORILLATUM*) FROM SOUTHEAST ASIA (ACARINA, TROMBICULIDAE)[1]

By M. Nadchatram[2] and Robert Traub[3]

Abstract: Three new species of *Leptotrombidium* (*Lorillatum*) chiggers from South Viet-Nam and Thailand are described and figured, bringing to 6 the total known to date. All infest rodents and tree-shrews in the hills and mountains of various countries of Southeast Asia. *L.* (*Lor.*) *kianjoei* n. sp. is separable from the other species with the palpal formula B/N/NNB in that it possesses only about 40 dorsal setae. *L.* (*Lor.*) *oreophilum* n. sp. is unique in the subgenus in possessing a palpal formula N/N/NNB. *L.* (*Lor.*) *panitae* n. sp. is distinctive in possessing 2 or 3 pairs of humeral setae instead of the usual single pair.

In studies on potential vectors and reservoirs of disease, teams from Bishop Museum, Honolulu, have been collecting specimens in South Viet-Nam and other Asiatic-Pacific areas with the support of the Army Medical Research and Development Command and the National Institutes of Health, Washington, D. C. Concurrently, the SEATO Medical Research Laboratory, Bangkok, has been investigating the ecology of scrub typhus in Thailand. Both of these programs have consistently enhanced our knowledge of the fauna of trombiculid mites, especially of *Leptotrombidium*, a genus wealthy in numbers of species and individuals in Southeast Asia, and of particular interest because it includes the classical, and presumably most important, vectors of scrub typhus.

The subgenus *Lorillatum* Nadchatram, 1963, was established to include those species of *Leptotrombidium* in which some of the legs bear long whip-like setae (which may be basally barbed). To date, three species are known, viz.: *L.* (*Lor.*) *flagelliferum* (Traub & Audy 1954) and *L.* (*Lor.*) *tuhanum* (Traub & Audy 1954) both from Sabah (N. Borneo), Malaysia, and *L.* (*Lor.*) *mastigophorum* Nadchatram, 1963, from Laos. Three new species of *Lorillatum*, from Thailand and South Viet-Nam, are described and illustrated herewith, and *L. mastigophorum* is reported from Thailand for the first time. A key to the species is presented following the descriptive portions of the article.

The holotypes of the three new species are deposited in the U. S. National Museum, Washington, D.C., and paratypes, as available, are deposited among the collections of the Institute for Medical Research, Kuala Lumpur; Bishop Museum, Honolulu; the British Museum (Nat. Hist.), London; the Hooper Foundation of the University of California, San Francisco; SEATO Medical Research Laboratory, Bangkok; the Rocky Mountain Laboratory, Hamilton, Montana; as well as in the collections of R. Traub and other acarologists.

Leptotrombidium (Lorillatum) mastigophorum Nadchatram, 1963, Pac. Ins. 5 (2): 473–77.

This species was described from Laotian material, but we now have specimens from Thailand as follows: 1 specimen ex *Rattus sabanus* (SMRL 1988); Khon Khaen, A. Chum Phae, Pa Song Larn, 24. XI. 1962; 1 specimen ex *Rattus niveiventer*, (SMRL 2092); Loei, A. Wangsapung, Phu Kra Dung, 1. XII. 1962; Coll.

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